

DISLOCATIONS OF THE CERVICAL SPINE IN RHEUMATOID ARTHRITIS

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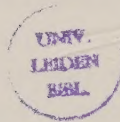
- I. Inga Redlund-Johnell and Holger Pettersson: Radiographic measurements of the craniovertebral region, designed for evaluation of abnormalities in rheumatoid arthritis. Accepted for publication in Acta Radiol Diagnosis 25, 1984.
- II. Inga Redlund-Johnell and Holger Pettersson: Vertebral dislocation of the C1 and C2 vertebrae in rehumatoid arthritis. Accepted for publication in Acta Radiol Diagnosis 25, 1984.
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- VI. Inga Redlund-Johnell: Subaxial vertical dislocation in rheumatoid arthritis. Submitted for publication in Neuro-radiology.

These papers will be referred to, in the text, by their roman numerals I - VI.

ABBREVIATIONS

RA = rheumatoid arthritis

CT = computed tomography



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INTRODUCTION

The cervical spine has a great range of mobility, and because of its great flexibility and little stability the cervical spine offers less protection to the central nervous system, i.e., the medulla oblongata, spinal cord and to the vessels and nerves, than the skull to the brain and the relatively immobile thoracic spine to the lower spinal cord. On the cervical spine there is a load of about 6.5 kg, that, is the weight of the head, which is balancing on the atlas (5).

When there are lesions of the joints of the cervical spine, as in trauma or rheumatoid arthritis (RA) there will be possibilities for different types of dislocations to occur between the vertebrae and sometimes injury to the central nervous system. Therefore, one of the most dangerous threats to the RA patient is the cervical affection (31). A rheumatoid arthritic affection of the peripheral joint gives more apparent local symptoms and difficulties in daily life (47, 56, 80). But a deterioration resulting in the patient being confined to a wheelchair might be due to a cervical affection with cord compression, and thus not always on peripheral joint impairment.

In the diagnostic work up of cervical RA, the radiological examination is of utmost importance (5). Although during the last 30 years several reports of different types of cervical dislocations have appeared, these reports have been based on very different materials and therefore are not fully comparable. Thus, there is a need for a radiological investigation of all the different types of cervical dislocation occurring in one defined population. Below, such a study will be presented, preceded by a review of the present knowledge of normal anatomy and pathological changes in RA of the cervical spine.

ANATOMY OF THE CERVICAL SPINE

The cervical spine (Figs. 1 and 2) consists of seven verte-

brae, where the upper two are different from typical vertebrae. The first vertebra, the atlas, may be described as a ring which is able to rotate around a former, eccentric centre (132), in which the odontoid process (dens) is located (Fig. 3a). The second vertebra, the axis, is a typical vertebra except for the odontoid process, extending upwards from the body of the axis into the atlas ring (Fig. 3 b). The dens has an anterior articular facet facing the posterior aspect of the anterior arch of the atlas, comprising the anterior atlanto-axial joint. There is also a posterior articular facet of the dens facing the synovial joint between the dens and the transverse ligament, which connects the medial aspects of the two lateral masses of the atlas. From the transverse ligament there are longitudinal bands up to the clivus and down to the body of the atlas. Together, they form the cruciform ligament (Fig. 3 a-c). This ligament is covered by the tectorial membrane, which in turn is covered by the

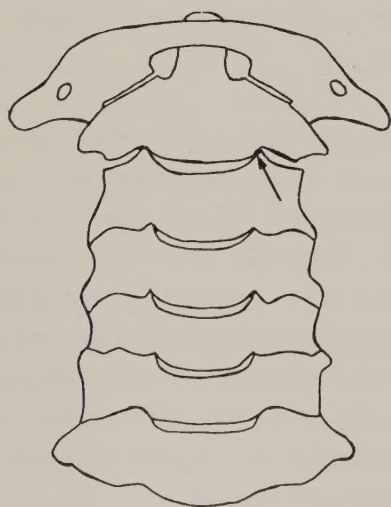


Fig. 2. Lateral view of the cervical spine. Arrow marks one of the apophyseal (intervertebral) joints.

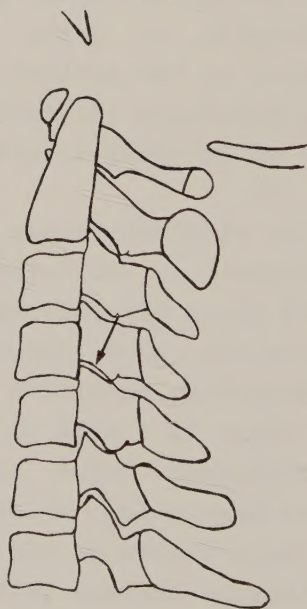


Fig. 1. Frontal view of the cervical spine. Arrow marks one of the uncovertebral joints.

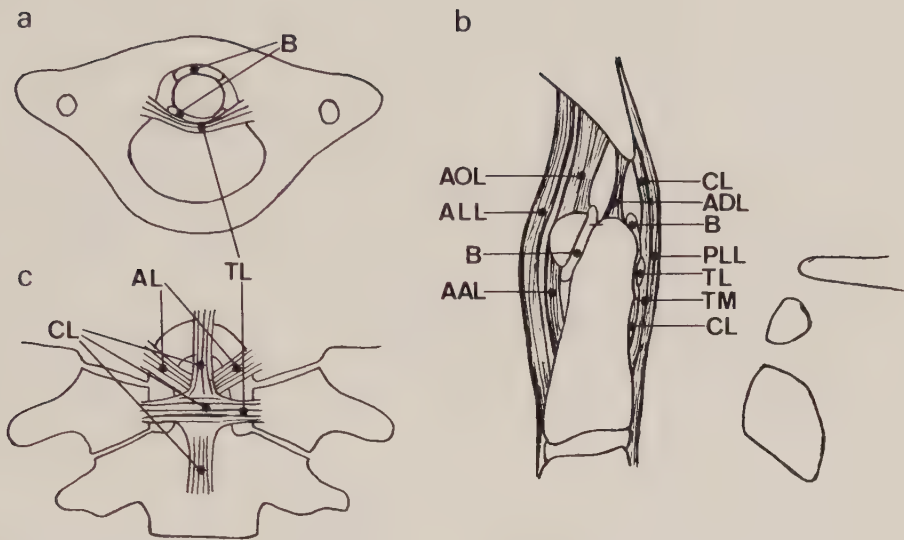


Fig. 3. The atlanto-axial joint. a) transversal section, b) midsagittal section, c) antero-posterior section. AAL= anterior atlanto-axial ligament, ADL= apical dental ligament, AL= alar ligaments, ALL= anterior longitudinal ligament, AOL= atlanto-occipital ligament, B= bursa, CL= cruciform ligament, PLL= posterior longitudinal ligament, TL= transverse ligament, TM= tectorial membrane.

posterior longitudinal ligament. The apical dental ligament connects the apex of the dens to the ventral part of the foramen magnum, and the alar ligaments connect the lateral parts of the dens with the lateral parts of the foramen magnum (33). Frontally, there are the occipito-atlantal, the atlanto-axial, and the anterior longitudinal ligament.

There are apophyseal joints (intervertebral joints) from the occiput downwards in the whole cervical spine (Figs. 2 and 3). The articular facets are orientated mainly in a horizontal plane in the occipito-atlantal and atlanto-axial joints, which make

them more liable to dislocations than the corresponding joints below, which are located in a more vertical plane. These apophyseal joints are true synovial joints.

From the C2 vertebra and downwards there are discs between the vertebral bodies. Besides, there are uncovertebral joints between the peripheral bowing parts of the end plates of the cervical vertebral bodies (Fig. 1) with anatomical features of both cartilaginous and synovial articulations (6, 102). Bursae lined with synovia may be present in normal cases between the top of the dens and the clivus (132) and between the spinous processes, more seldom in normal cases but rather frequently in RA (17).

REVIEW OF THE LITERATURE ON RHEUMATOID ARTHRITIS OF THE CERVICAL SPINE

A. PATHOGENESIS

Rheumatoid arthritis is primarily a disease involving the synovia and small blood vessels (5), but other connective structures may be involved such as the cartilaginous joints (symphysis pubis and manubrosternal joints), entheses (tendon and ligament attachment), and discovertebral articulations (102). Synovial joints in the cervical spine as the apophyseal joints are affected by RA just as are other synovial joints of the body. Enthesopathy may cause erosions of the spinous processes. There is some discussion about the pathogenesis of discovertebral affection (102) but most authors belong to the "synovial" school (3, 5, 16, 37) and thus regard it as an extension of the rheumatoid process from the uncovertebral joints. The "traumatic" school (73) regards the affection as a consequence of chronic discovertebral trauma secondary to apophyseal joint instability, and the "enthesopathic" school (114) as caused by affection of spinal entheses. Fibrinoid necrosis and inflammation are the cause of pathological laxity, and destruction of the transverse ligament will result in an anterior atlanto-axial (horizontal)

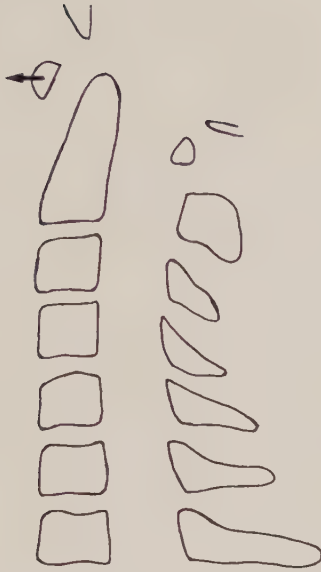


Fig. 4. Anterior (horizontal) atlanto-axial dislocation.



Fig. 5. Posterior atlanto-axial dislocation.

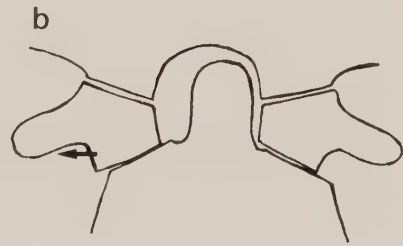
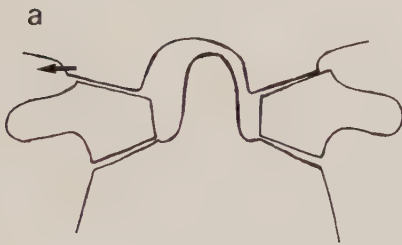


Fig. 6. a) Lateral occipito-atlantal dislocation. b) Lateral atlanto-axial dislocation.

dislocation (Fig. 4; 5, 75). If a pronounced horizontal dislocation appears, there must be damage not only to the transverse ligament but also to the alar ligaments and tectorial membrane (132). If there is a destruction or a fracture of the dens a posterior atlanto-axial dislocation may appear (Fig. 5).

Rheumatoid lesions may appear in the intervertebral (apophyseal) and uncovertebral joints; and with affections of the occipi-



Fig. 7. Vertical (occipito-)atlanto-axial dislocation

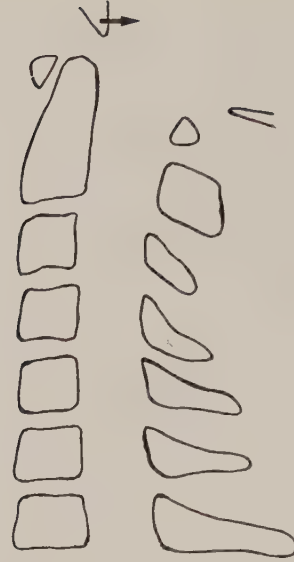


Fig. 8. Atlanto-occipital dislocation.

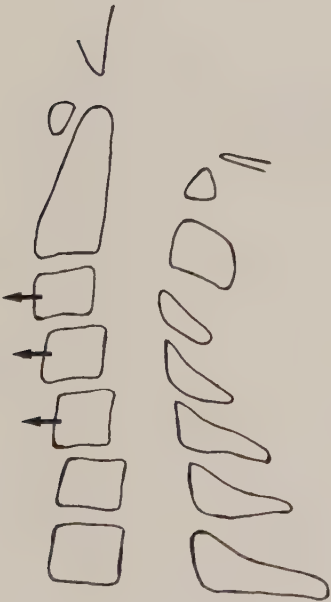


Fig. 9. Subaxial antero-posterior dislocation.

to-atlantal and atlanto-axial intervertebral joints, the result will be a lateral (Fig. 6 a + b), a vertical occipito-atlanto-axial (Fig. 7) or a (horizontal) atlanto-occipital dislocation (Fig. 8). With affections of the lower apophyseal and uncovertebral joints, together with lesions of the discs, there will be dislocations which have been referred to as subaxial (=below axis or C2), staircase, or serial dislocations (Fig. 9).

RA can also primarily affect the dura mater, with thickening and fibrosis which may lead to

encroachment of the space of the spinal canal and with consecutive injury to the spinal cord but without evidence of bony compression (53, 57). Similar dural nodules have been reported to exist intracranially (68). Attention has also been drawn to the vertebral vessels especially in their passage through the craniovertebral region. Kinking of them, as in atlanto-axial dislocations may lead to symptoms of vertebral artery insufficiency, which may be relieved by cervical fusion (29). A fatal case of bilateral vertebral artery thrombosis in tortuous vessels has been reported (128), and also a case with vertebral arterial insufficiency due to compression of the arteries by the top of the dens in a patient with a vertical atlanto-axial dislocation (115).

B. CERVICAL DISLOCATIONS

In the present investigation, the term "cervical dislocation" is used to describe the malalignment between the vertebrae. In the literature, the term "subluxation" is more common, but since a malalignment may include any degree of total or subtotal luxation between the vertebral bodies and the articular parts of the apophyseal and uncovertebral joints, respectively, the term "dislocation" has been chosen. As stated above, several types of such dislocation are possible in RA of the cervical spine.

A.E.Garrod (1890) is regarded to be the first to report about rheumatoid involvement of the cervical spine (41). He found a cervical affection in 35% of his 500 patients, but he did not specifically mention dislocation. His findings on cervical RA were more or less forgotten until 1951, when the report by Davis and Markley (31) of a fatal case appeared.

Occipito-atlanto-axial dislocations

The first description of a nontraumatic atlanto-axial dislocation is attributed to Sir Charles Bell in 1830. He had a patient with a penetrating syphilitic ulcer in the back of his throat.

Suddenly the patient got apoplectic-like symptoms. Two hours later, the head of the patient fell forward and he expired instantly. On dissection, the transverse ligament was seen to be destroyed and Bell realized that the odontoid process could have had compressed the spinal marrow (33, 36, 118). Later, antero-posterior dislocations were found in children with severe inflammatory disease affecting the upper cervical region (46). About the same time, there were reports of arthritis of the cervical spine with atlanto-axial dislocation (45, 117). These cases seem to have been due to ankylosing spondylitis rather than to RA. Englander (36) lists RA as a cause of "spontaneous atlantoaxial dislocation" in a case report with suppurative submaxillary lymphadenitis. In 1951, the first report of a fatal RA case (31) appeared and since then there have been several reports of dislocations in RA. This first fatal case was due to a vertical atlanto-axial dislocation (Fig. 7), but the interest was initially focused on the more easily detected anterior (horizontal) atlanto-axial dislocation (Fig 4; 1, 2, 5, 7, 9, 10, 19, 24-26, 28, 29, 32, 37, 38, 42, 43, 47, 50, 52, 55, 58, 63, 64, 71, 72, 74-77, 83, 84, 88-94, 97, 100, 101, 103, 107, 109, 110, 112, 113, 116, 118, 120, 123, 124, 127, 130, 135, 137, 138).

Later on, the vertical dislocation (Fig. 7) was also studied (2, 5, 7, 8, 10, 19, 22, 24, 25, 29, 30, 34, 35, 37, 44, 47, 50, 54, 55, 64, 67, 71, 72, 75-79, 83, 86-89, 92, 93, 95-98, 110, 111, 113, 115, 116, 121, 123, 124, 127, 128, 129, 130, 137, 138).

More rare dislocations such as posterior atlanto-axial dislocation (Fig. 5; 29, 33, 40, 51, 59, 88, 122, 129-131, 136) or atlantooccipital dislocation (Fig. 8; 27, 89, 127) have also been reported. Only recently there have been studies on cases with lateral atlanto-axial dislocation (Fig. 6 13, 14, 49, 119, 129).

Subaxial dislocations

After the recognition of the hazards of arthritic dislocation,

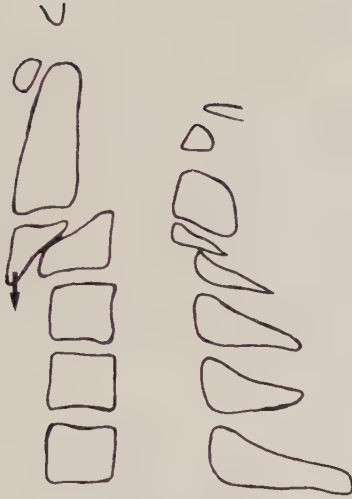


Fig. 10. Subaxial vertical dislocation.

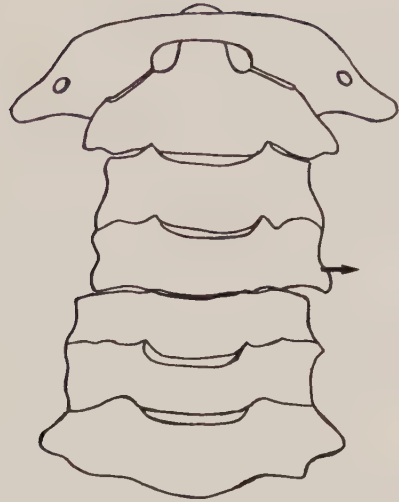


Fig. 11. Subaxial lateral dislocation.

the interest, as mentioned above, was first focused on the horizontal atlanto-axial dislocation, but also reports of subaxial (= below axis or C2) dislocation (Fig. 9) appeared as early as 1952 (63). One case, considered as one of the earliest with arthritic subaxial (antero-posterior) dislocation, describes a patient with a disease that was ankylosing spondylitis rather than RA (70). In subsequent years, additional reports of subaxial RA dislocations appeared (5, 19, 24, 38, 47, 50, 52, 64, 69, 71, 73, 83, 88, 92, 93, 107, 111, 116, 124, 127, 137). To date, there does not appear to have been any previous report of a subaxial vertical dislocation (Fig. 10) and only single cases with a lateral subaxial dislocation (Fig. 11).

C.CLINICAL CHARACTERISTICS

There are no pathognomonic clinical characteristics of cervical RA. Sometimes there are no cervical symptoms, but often there are mild local symptoms. Often the patients complain more of the symptoms from the peripheral joints, which makes the daily life difficult (47). A correlation has also been reported between the severity of RA of the hands and of the cervical spine (4, 19, 64, 65, 98, 107). To the rheumatologist, the patient may present without symptoms and yet at a pre-operative radiographic examination or at autopsy there will be extensive changes (5, 86).

On the other hand more or less severe local symptoms do exist. Usually there is pain in the neck and occiput, sometimes radiating to the eye or paranasal sinuses. The neurological symptoms vary from mild paresthesias, swallowing disturbances, loss of deep tendon reflexes, positive Babinski sign, micturition disturbances, weakness of both upper and lower extremities to quadriplegia and death (5, 23, 25, 29, 30, 31, 34, 35, 40, 43, 44, 47, 48, 50, 51, 53, 54, 60, 61, 66, 69, 71, 74, 76, 77, 79, 83, 85-87, 93, 94, 96, 103, 108, 111-113, 115, 116, 118, 119, 123, 128, 129, 130, 136, 138).

At examination there might be tenderness of the cervical spine and restricted motion. The neck may be shortened with the shoulders just below the ears. With the neck flexed, a bony prominence may be seen in the suboccipital region in the midline. This prominence corresponds to the spinous process of the axis, which may be seen dislocated backwards with regard to the occiput in an anterior atlanto-axial dislocation. The patient may feel or hear crepitations with certain cervical movements. But a radiographic examination is superior to a clinical examination for the diagnosis of cervical RA (5).

AIM OF THE PRESENT STUDY

The purpose of the present study was to investigate:

1. The frequency, severity and radiological course of different cervical dislocations in patients with RA (Papers II-VI).
2. The distribution of these dislocations according to age and sex (Papers II-VI).
3. The relationship between cervical dislocations, other arthritic cervical abnormalities, and postoperative states (Papers II-VI).
4. The relationship between cervical dislocations, encroachment on the cervical spinal canal, other arthritic abnormalities, and the occurrence of neurological symptoms (Papers II-VI).
5. The occurrence of congenital anomalies, possibly predisposing to rare dislocations such as posterior atlanto-axial or atlanto-occipital dislocation (Papers III and IV).

To achieve some of the above-mentioned goals, it appeared necessary to find:

1. A method for measuring a vertical atlanto-axial dislocation that would be more useful and reliable in a retrospective material (Paper I) than the methods on record (12, 21, 39, 81, 82).
2. Normal measurement values for this new method, as well as for the McGregor method, which are applicable to a present-day Scandinavian population (Paper I).
3. A possible correlation between the values obtained with this new method and those obtained with McGregor's method (Paper I).

MATERIALS

Radiographic examinations of the cervical spine

The routine examinations of the cervical spine have been performed with a film-focus distance of 150 cm and 70 kV. Usually the cervical examinations consist of one anteroposterior, two oblique, and one lateral projection. With a certain or supposed diagnosis of RA, since 1973, two lateral projections - one in flexion and one in extension, have always been taken, and sometimes also a lateral projection in the neutral position. As a pre-operative examination, usually only the lateral projections in flexion and extension are taken.

Film archives

At Malmö General Hospital and Värnhem Hospital, also in Malmö, in southern Sweden, serving a population of 230,000 inhabitants, radiographs are recorded and filed in consecutive order according to the examined organ. If several skeletal areas are radiographed at the same time, the different skeletal examinations are collected in the same file. All radiographs obtained since 1950 have been studied in all patients.

A. MATERIALS IN PAPER I

1. Normal material
2. RA material

1. Normal material

The normal material was collected to determine normal values for the new measuring method of vertical dislocations. It consisted of consecutive examinations of the cervical spine in adults performed in 1980 at Malmö General Hospital because of pain, trauma, or possible metastatic lesions. Technically incomplete examinations (earrings covering the examination field

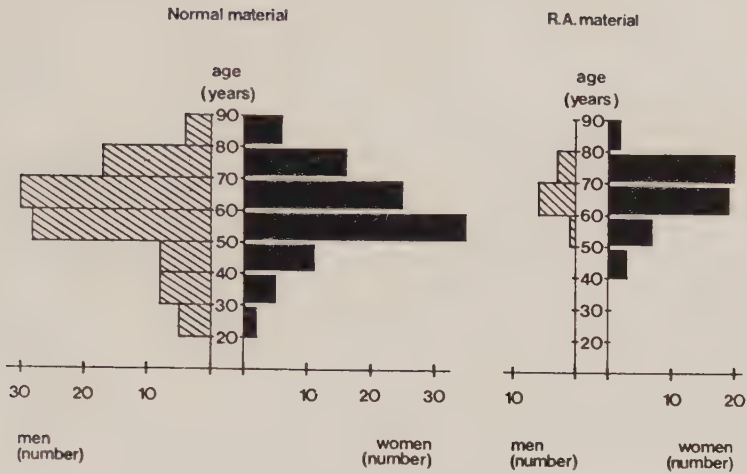


Fig. 12. Distribution according to age of 100 men and 100 women, constituting material I (normal material), and of 10 men and 51 women with RA composing material II (RA-material).

or part of the cervical spine or the posterior part of the hard palate outside the field) were excluded, as were examinations in patients with RA, and those with collapsed vertebrae due to trauma or tumour. The first 100 patients of each sex satisfying these demands were collected. The distribution according to age and sex is given in Fig. 12.

2. RA material

The RA material consisted of 61 patients with a radiographic examination of the cervical spine performed during 1973 through 1980. These patients were taken from materials I and II (see below), and comprised all the patients of these materials with a vertical dislocation according to the method proposed by McGregor (81), i.e., a distance of more than 4.5 mm between the apex of the dens and the palato-occipital line. The distribution according to age and sex is given in Fig. 12.

B. MATERIALS IN PAPER II-VI

1. Material I
2. Material II
3. Combined material (I+II)

1. Material I

During the period 1978 through 1980, there were 4,872 cervical examinations filed and another 6,504 in collection files, and all of these examinations were reviewed.

All the examinations with lateral projections, in flexion and extension were collected. The radiographic charts of the patients with two laterals were checked for the clinical diagnosis of RA. In 5-10% of the patients there were other arthritic diseases, like ankylosing spondylitis, or a history of trauma or pain, and these patients were excluded. In this way, 402 adult patients with RA were found, and of these 172 had a cervical affection.

Also all the examinations without two lateral projections were scrutinized for arthritic changes, and the radiological charts of the patients with suspected arthritis were studied. In this way, another five adult patients were added.

Patients without a history of RA on the admission note, and therefore with only one performed lateral projection and without arthritic changes of the cervical spine, may thus have been missed. During the years 1981 and 1982 the charts of all RA patients, referred for any radiological examination from the rheumatology department have been checked in order to find such possibly missed patients, but none were found.

Thus it seems probable that practically all patients with a history of RA and a cervical examination during the period 1978-1980 would have been included in material I. Only one child was, however, found and was excluded from the material.

Thus, 407 patients were found, and they constitute the material I.

2.Material II

In order to enlarge the material of pathological cervical radiographs, all patients with RA who were not examined during the period mentioned and who had the radiological diagnosis of arthritis of the cervical spine at one of the two Malmö hospitals during the period 1973 through 1977 were included. Thus, another 43 adult patients with RA were found, and they constitute material II.

3.Combined material,I and II

The distribution of age and sex in materials I and II is shown in Fig. 13.

All cervical radiographs from 1950 and later of the patients

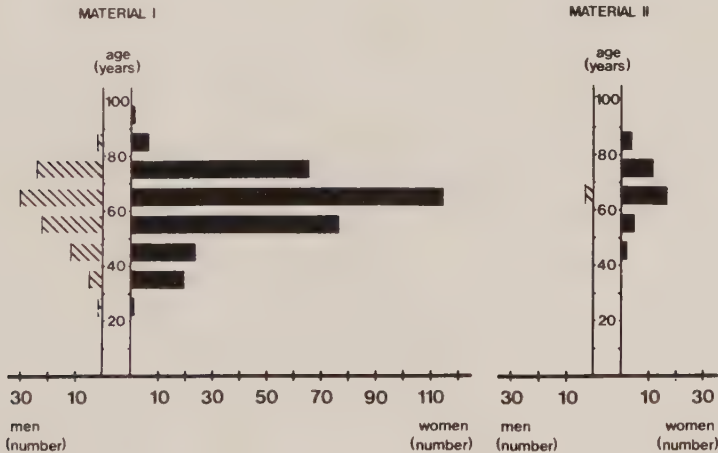


Fig. 13. Age and sex distribution of material I comprising 407 patients with RA who had had radiography of the cervical spine performed in 1978-1980 and of material II of another 43 patients with radiography performed in 1973-1977.

with RA were collected, and so were their hypopharyngeal, tracheal, and skull examinations. In some patients it was possible to follow the progress of cervical RA for a period of about 25 years.

In all, there were 1,026 examinations of the 450 patients of the combined materials. Patients without any arthritic changes usually had undergone fewer examinations than those with advanced changes. There were 177 patients in material I and 43 in material II, in all 220 patients with an arthritic affection of the cervical spine, and in these patients 683 examinations of the cervical spine had been performed.

26 patients, all with severe changes of the cervical spine, had had a conventional tomography in the frontal or lateral projection, and in another 10 cases computed tomography had been performed. No cervical myelography was performed and only one patient of the 450, a case without cervical arthritis, had had an aortocervical angiography performed.

METHODS

In materials I and II all the collected radiographs were reviewed for the location of dislocations, as well as for erosions, and this was related to age, sex, and duration of disease. The course of the dislocation with time was recorded, as was the interrelationship between the different types of dislocation and between types and degrees of dislocation, erosions, encroachment on the cervical spinal canal, and neurological disturbances.

DEFINITIONS AND MEASUREMENTS

1. Anterior (horizontal) atlanto-axial dislocation (Fig. 4)
This was measured from the lower posterior border of the anterior arch of the atlas to the nearest part of the dens, and a value exceeding 3 mm was regarded as pathological (56, 92, 100).

2. Posterior (horizontal) atlanto-axial dislocation (Paper III; Fig. 5). This was said to exist when the the posterior aspects of the anterior arch of the atlas was posterior to the anterior border of the body of the C2 vertebra.

3. Vertical (occipito-) atlanto-axial dislocation (Paper I and II, Fig. 7). This dislocation was measured using the palato-occipital line (McGregor's line). Because a change in the perpendicular distance from that line to the centre of the lower end plate of the vertebral body of the C2 vertebra is one expression of a vertical dislocation of the C1 and C2 vertebrae, this distance was measured. Also, the distance from the apex of the dens to the palato-occipital line according to McGregor was recorded (Fig. 14).

4. Lateral (occipito-) atlanto-axial dislocation (Fig. 6) This was impossible to detect with certainty in all the patients of the two materials, and the frequency of this dislocation was therefore not investigated. Only a few patients had had examinations performed that were designed to discover lateral disloca-

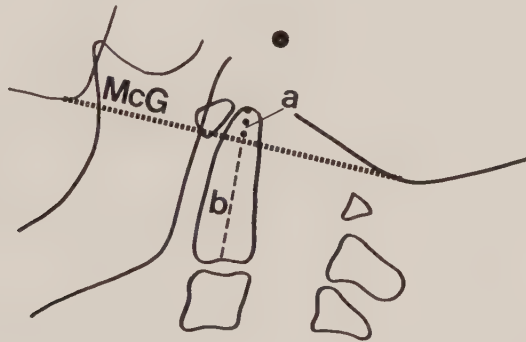


Fig. 14. Measurement method. McG= the palato-occipital line or McGregor's line. a= the distance between the apex of the dens and McG. If the apex of the dens is situated below this line, the value will be negative. b= the distance between the lower end plate of the C2 vertebra and McG.

tion: open-mouth antero-posterior projection, frontal tomography, or computed tomography.

5. Atlanto-occipital dislocation (Paper IV; Fig. 8). This dislocation was said to exist when the posterior arch of the atlas was situated in front of the posterior border of the foramen magnum or if the anterior arch of the atlas was lying behind the anterior edge of the foramen magnum.

6. Subaxial antero-posterior dislocation (Paper V; Fig. 9). This was said to exist when the distance between the posterior borders of two adjacent vertebrae was more than 2 mm (105), and a distance of 4 mm or more was regarded as a severe dislocation.

7. Subaxial vertical dislocation (Paper VI; Fig. 10). This dislocation was said to exist when the lower end plate of a vertebral body was dislocated to the same plane or lower than the upper end plate of the caudad vertebra.

8. Subaxial lateral dislocation (Fig 11). This was defined as a lateral dislocation of one vertebral body from an adjacent vertebral body.

9. The sagittal diameter of the cervical bony canal. This was measured at the level of dislocation between the posterior border of the vertebral body and the nearest point on the ventral line of the cortex, seen at the junction of the spinous process and lamina.

10. The height of the cervical spine. This was measured from the skull base above the atlas to the lower anterior part of the end plate of the C7 vertebra.

MEDICAL HISTORIES OF THE PATIENTS

Admission notes

The admission notes (radiological charts) of every RA patient

to the radiology departments were reviewed, and duration of disease, local symptoms from the neck, and neurological symptoms were noted.

Autopsy reports

The autopsy records from the deceased patients with radiological cervical changes were reviewed for reports of investigations of the cervical spine.

Hospital charts

In patients with advanced radiographic changes, the hospital charts were also studied in order to possibly find a correlation between radiographic changes and neurological symptoms, perhaps not mentioned in the admission notes to the radiological departments.

STATISTICS

Statistical analysis was performed with the help of the χ^2 -test, the Student's t-test, and linear regression.

RESULTS OF EACH PAPER (I-VI)

RADIOGRAPHIC MEASUREMENTS OF THE CRANIOVERTEBRAL REGION, DESIGNED FOR EVALUATION OF ABNORMALITIES IN RHEUMATOID ARTHRITIS (Paper I)

The distance from McGregor's line to the lower end plate of the C2 vertebra (Fig. 14) of the normal and the RA material is presented in Table 1. The distance was significantly longer in men than in women, but did not change with age. The normal

Table 1.

Distance between McGregor's line and lower end plate of the body of the C2 according to age and sex.

Sex	Age	Number	Distance between the end plate of C2 and McGregor's line (mm)
NORMAL MATERIAL			
Men	20-89	100	41.6±4.0
	(20-39)	(13)	(41.7±4.9)
	(70-89)	(21)	(41.7±4.3)
Women	20-89		37.1±4.3
	(20-39)	(7)	(39.6±4.3)
	(70-89)	(22)	(36.2±3.9)
RA MATERIAL			
Men	59-77	10	32.2±4.9
Women	43-80	51	28.7±4.3

Table 2.

Distance from McGregor's line to the apex of the dens according to age and sex

Sex	Age	Number	Distance from apex of the dens to McGregor's line (mm)
NORMAL MATERIAL			
Men	20-89	100	2.4±3.2
	(20-39)	(13)	(1.8±3.5)
	(70-89)	(21)	(1.8±2.4)
Women	20-89	100	2.5±3.3
	(20-39)	(7)	(0.5±3.6)
	(70-89)	(22)	(3.0±3.4)
RA MATERIAL			
Men	59-77	10	10.2±3.3
Women	43-80	51	9.3±3.7

lower limit (mean value - 2 SD) was 29.5 mm in women and 33.5 mm in men, respectively. Table 2 gives the distance between the apex of the dens and the palato-occipital line. The normal upper limit was 9.0 mm in women and 9.5 mm in men. There was a good correlation between the distance (x) from McGregor's line to the lower end plate of the C2 vertebra and the distance (y) from that line to the apex of the dens. In the combined material the correlation coefficient was -0.784 for men and -0.921 for women.

VERTICAL DISLOCATION OF THE C1 AND C2 VERTEBRAE (Paper II)

Vertical dislocation was found in 42 patients of material I (10%) and in 20 patients of material II. The mean age of the patients was 63 years and the mean duration of disease was 22 years.

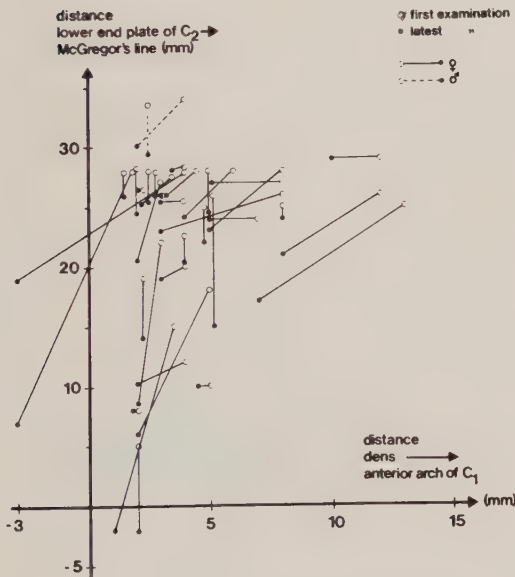


Fig. 15. The change in vertical dislocation in relation to a coincident change in horizontal dislocation in the 37 patients with a follow-up examination.

The new measurement method was possible to use in all cases, but it was impossible to use the McGregor method in 10% of all the cases and in every case with a severe vertical dislocation.

Temporal progression of the vertical dislocation was seen in 81%, and in no case was there any improvement.

A horizontal atlanto-axial dislocation was found at an earlier cervical examination in nearly all cases. After the appearance of the vertical dislocation, the horizontal dislocation diminished or disappeared in most cases

(Fig. 15). Erosive lesions of the C1 and C2 vertebrae were significantly more often present in patients with than without a vertical dislocation.

A subaxial dislocation occurred in 58% of the patients, but it was not found more often in patients with a severe vertical dislocation.

Neurological symptoms occurred significantly more often in patients with than in patients without a vertical dislocation and similarly in patients with a severe rather than a mild dislocation. Among the 13 patients in whom a postmortem examination of the cervical spine was performed, the vertical dislocation was found to have been a main or contributory cause of death in 6 patients. Neurological symptoms were significantly more common among patients with a narrow spinal canal (sagittal diameter <13 mm) than among those with a wide canal.

POSTERIOR ATLANTO-AXIAL DISLOCATION (Paper III)

In material I there were 5 patients with a posterior dislocation (1,2%) and in material II, another 2 cases. All the patients were elderly women with a disease of long duration. Cervical examinations performed before the appearance of the posterior dislocation were available in all cases and there was no congenital anomaly. In 3 patients the posterior dislocation appeared during extension of the neck and the dislocation was transformed into an anterior dislocation with the neck in flexion. These 3 cases had no vertical dislocation, which was found in the other 4. There appeared to be no encroachment on the spinal canal in the craniovertebral region.

ATLANTO-OCCIPITAL DISLOCATION (Paper IV)

There were 2 patients with an atlanto-occipital dislocation in each material, corresponding to a frequency of 0.5% in material

I. Three patients had an anterior dislocation of the occiput and one a posterior dislocation. All 4 patients also had vertical atlanto-axial and subaxial dislocations, and all had neurological symptoms. One of the patients had refused conventional therapy except acetylsalicylic acid and confined herself to "natural remedies". In 2 patients a cervico-occipital fusion was performed after which there was relief of the symptoms, but in one patient there was a recurrence of the symptoms after a week and a cervical radiograph revealed an insufficient fusion. The 2 patients who were not operated on, died relatively soon after the detection of the dislocation, and an autopsy performed in one revealed a compression on the medulla oblongata.

SUBAXIAL ANTERO-POSTERIOR DISLOCATION (Paper V.)

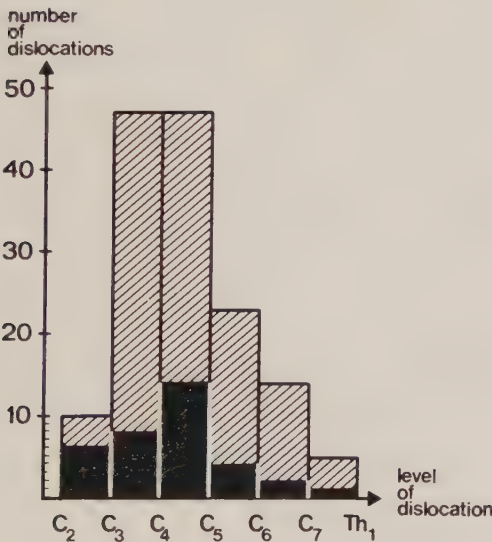


Fig. 16. Distribution of dislocations according to cervical level and severity of dislocations. Black area: severe dislocation (of 4 mm or more), dashed area: mild dislocation.

In material I there were 73 patients with a subaxial antero-posterior dislocation which gives a frequency of 18%. In material II another 20 patients were found, and thus the combined material comprised 93 patients with a mean age of 65 years and a disease of 20 years duration.

A dislocation at only one level was found in 48 patients. The distribution of dislocations at different levels are presented in Fig. 16. A severe dislocation was found in 30 patients and 8 patients had a severe affection at two or more levels. A progression

was found after 2 years or more in 31% and an improvement in only 1 patient.

A subaxial antero-posterior dislocation occurred significantly more often in patients with an atlanto-axial dislocation than in patients without it.

In patients with severe a horizontal atlanto-axial dislocation, the development of a subaxial dislocation did not occur more often in patients treated with cervico-occipital fusion than in patients treated conservatively.

A subaxial dislocation appeared significantly more often in patients with a diminished height of the spinous process than in patients with preserved heights.

Neurological symptoms occurred significantly more often in patients with a narrow spinal canal (sagittal diameter <13 mm) than in patients with a wide canal, as well as they did in patients with a diminished height of the whole cervical spine. Four patients had tetraparesis, and one of them had a dislocation of only 3.5 mm but had a congenitally narrow canal. In at least 5 patients the neurological symptoms subsided without treatment. One of the patients with tetraparesis was successfully treated with posterior fusion.

SUBAXIAL VERTICAL DISLOCATION (Paper VI)

In material I there were 4 patients (1%) with a subaxial vertical dislocation and another 3 cases were found in material II. All 7 patients had an antero-posterior dislocation at the same level. The vertical dislocation occurred at two cervical levels in 2 patients. The 7 patients were middle-aged or elderly women with a disease of long duration. The dislocation varied between 2 and 18 mm, e.g., up to as much or more than the height of one vertebra.

Neurological symptoms occurred in 6 patients. In 3 of these patients the sagittal diameter of the spinal canal was reduced at the atlanto-axial level but not at the subaxial level. In 1 patient with subaxial mild encroachment on the spinal canal the symptoms of arm weakness subsided after 3 weeks.

GENERAL RESULTS NOT MENTIONED IN THE PAPERS

The mean age of the 177 patients of material I with cervical arthritis was 62.7 years (range 34-92 years) and of the 230 patients without cervical affection it was 60.3 years (range 20-85 years); thus, there was no difference. The distribution according to age and sex of patients with and without cervical RA are presented in Fig. 17.

The mean duration of disease in the 220 patients of the combined material with cervical RA was 18.8 years for men and 22 years for women: This was significantly longer than in the pa-

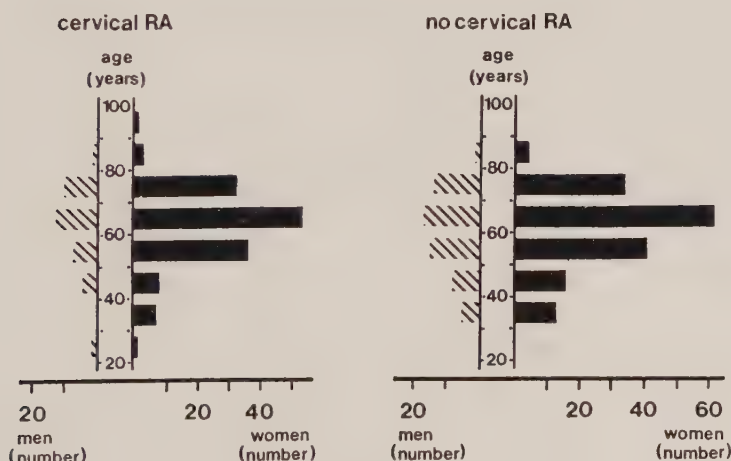


Fig. 17. Distribution according to age and sex of patients of material I with and without cervical RA.

tients without cervical RA, whose mean duration of disease was 10.9 years 12,7 years respectively ($0.01 < p < 0.001$).

Anterior horizontal atlanto-axial dislocation

Among the 177 patients in material I with cervical arthritis, there were 131 patients (32% of the whole material) with anterior (horizontal) dislocation detectable on at least one examination.

Lateral occipito-atlanto-axial dislocation

In the combined material there were 10 patients with a frontal tomography, and among them were 4 patients with a lateral dislocation, whereas among the 10 with a computed tomography there were 2 cases. These 6 patients had also a vertical atlantoaxial dislocation. The others were thus not possible to study.

Table 3.

Number and frequency of different cervical arthritic changes of material I (all RA patients with a cervical radiographs performed 1978-1980).

	Type of dislocation	Number	Frequency
Cranio-vertebral region	Anterior	131	32%
	Vertical	42	10%
	Lateral	unknown	unknown
	Posterior	5	1%
	Atlanto-occipital	2	0.5%
Subaxial region	Antero-posterior	73	18%
	Vertical	4	1%
	Lateral	0	0%
Only erosive lesions	None	24	6%

Subaxial lateral dislocation

No patient with this dislocation was found in the two materials.

Cervical RA without dislocations

Among the 177 patients in material I with cervical arthritis, there were 24 patients without any cervical dislocation, giving a frequency of 6% of the whole material I. These patients had erosions of vertebral bodies, and apophyseal joints, but most often of the spinous processes.

In material II there were 2 patients without dislocations, and thus with only erosive changes.

A survey of the different arthritic changes of material I is presented in Table 3.

AUTOPSY REPORTS AND PATIENT CHARTS

In all the cases from Värnhem Hospital, a thorough study of the cervical spine had been undertaken and the findings at autopsy were in good agreement with the radiological findings. At postmortem examinations at Malmö General Hospital the cervical spine was examined in about 70% of the cases, and also in these there was a good agreement with the radiological findings.

GENERAL DISCUSSION

AD MATERIAL

The present investigation is retrospective and the materials may represent a selection. There might be an overrepresentation of patients with moderate and pronounced severity of the disease

in material I and with pronounced severity in material II. The investigation probably does not reflect the natural course of cervical RA, but rather the natural course in patients with a more severe RA.

Most patients in the two materials have received medical therapy. Many patients have had therapy with corticosteroids, but the exact number has not been determined. The role of corticosteroids in cervical RA is contradictory in previous investigations. In some there is a higher incidence of severe cervical changes with steroid therapy (55, 84, 98) and in others there is no connection reported (25, 118).

In the present retrospective study, some of the patients have been followed for about 25 years, and such a long "follow-up" time would hardly be possible to achieve in prospective studies. In many patients the course of the disease was at first mild but after about 10 years it changed into a more severe course, which is in accordance with the findings of Bland et al (4).

For many of the patients there were cervical radiographs available, which were taken before onset of the disease owing to the unique radiological archives of Malmö, with almost all performed radiographs preserved (from 1919 and to the present day). In previous papers a comparison with radiographs taken before the onset of disease does not seem to have been done. However, examinations after onset of disease, but before apparent arthritic changes of the neck, do exist (93, 137).

This material, with 450 patients (407 + 43) with RA and cervical radiography performed is one of the greatest on record, only three previous materials being larger (Table 4). Henderson (54) presented 476 cases but he only investigated vertical dislocation. Smith et al had 962 patients (116) and Chevrot et al 577 patients (22), but there were only 150 and 165 patients, respectively, with cervical arthritis. In Table 4 the previous investigations with materials of more than 50 patients are presented.

Table 4.

Investigations with materials of 50 patients or more with RA and with cervical radiography performed among references. Name of authors and number of patients with RA and cervical RA are presented.

Authors	Number of patients in the material	Number of patients with cervical RA
Cabot & Becker	53	
Chevrot et al	577	165
Conlon et al	333	167
DeCarvalho & Graudal	188	
Gschwend et al	50	
Hancock	107	107
Henderson	476	
Hjort-Jensen	194	87
Mathews	76	
Meikle & Wilkinson	118	
Park & O'Brien	100	
Pellicci et al	106	74
Rasker & Cosh	62	
Serre & Simon	58	
Sharp & Purser	186	6
"	74	
Smith et al	962	150
Stevens et al	100	36
Thøbe	62	
Walcher et al	60	
Weissman et al	194	194
Winfield et al	100	33

AD METHODS

Radiographic examinations

The pre-operative radiological examination of patients with RA was in Sweden proposed by Werne as early as 1967 (133). As a routine pre-operative checkup, there is need for only two cervical lateral projections: one in flexion and one in extension with the whole cervical spine included, completed when necessary with an anteroposterior and two oblique views. The degree of dislocation can be measured but it is more important to recognize an en-

croachment on the cervical spinal canal (about 13 mm or less; 62, 139), so a remark on the diminished space for the medulla spinalis, or spinal cord, ought to be added by the radiologist.

When the dens is not discernible as in cases with a vertical dislocation, a pathological fracture of the dens, or severe osteoporosis, this should be mentioned together with a recommendation for further investigations in order to evaluate the possible risk of compression of the CNS. Specialized examinations should also be used when there is a posterior or an atlanto-occipital dislocation.

When more accurate examinations are needed, computed tomography (CT) has several advantages over conventional tomography. The CT examination can be performed with the patient supine, which is preferable for the crippled patient. Conventional radiography and standard tomography are encumbered by superimposition of the shoulders and cranium, and CT may detect also severely osteoporotic remnants of the dens, appearing intracranially in a vertical atlanto-axial dislocation. With modern CT equipment, the outlines of the CNS are detectable without contrast material injection and the exact level of spinal cord compression can be estimated (20, 61, 99). Lateral and rotatory dislocations can also easily be detected (61).

AD MEASURING METHODS

The vertical dislocation has been measured using several lines, such as Chamberlain's base line (21, 106), the palato-occipital line (81), the foramen magnum line (82), or the digastric line (39). McGregor's line is usually easy to define even in cases with severe vertical dislocation, and in most previous reports the vertical dislocation in RA was measured using this line or in advanced cases not measured, but estimated approximately.

The present method of measuring the distance from McGregor's

line to the lower end plate of the C2 vertebra can be used even in cases with advanced vertical dislocation, with the apex of the dens not discernible. The measurement points are easily defined and the correlation between the present method and McGregor's method is very good.

The values of the distance from McGregor's line to the apex of the dens, found in the present study, accord with earlier investigations (15, 76, 81, 104, 125, 126).

AD RESULTS

In material I 43% of the patients had arthritic changes of the cervical spine, which agrees with many earlier investigations (25, 33, 88). Also there was the same correspondence as regards age and sex distribution (19, 25, 37, 84, 94). The most common type of dislocation was the anterior atlanto-axial dislocation, present in 32% of our patients, which also earlier was reported to be the most frequent dislocation (25, 84, 89).

A subaxial antero-posterior dislocation was the second most common type of dislocation in material I, namely occurring in 18%, which accords with earlier investigations (25, 93, 108, 137). Further, mean age of the patients was concurrent (116).

A vertical dislocation was present in 10% of the patients of material I, a figure that also agrees with earlier reports (19, 50, 55, 76).

A lateral dislocation at the atlanto-axial level is known in traumatic cases (6) and also in RA (13, 14, 49, 129). Possibly, the lateral atlanto-occipital dislocation is the fourth most common type of dislocation, but in this retrospective examination it was impossible to determine, how many patients, that had this dislocation. When there is a severe anterior atlanto-axial dislocation, but no neurological symptoms, a lateral dislocation can be suspected. The spinal cord will then be located lateral to and slightly behind the dens and may thus escape compression

of the cord. With a CT examination the diagnosis will easily be settled. A lateral dislocation was reported to be present in 20.6% of the patients in a previous study (130).

A posterior atlanto-axial dislocation was found in 1% of the patients in material I, or in 2,8% in patients with cervical arthritic abnormalities, which is in agreement with Weissman et al (130).

An atlanto-occipital dislocation was present in 0.5% or in 2 cases, of material I, but as it was present also in 2 cases in material II, it is possibly not as rare as the earlier 3 isolated reported cases would indicate (27, 89, 127).

A subaxial vertical dislocation, which was present in 1% of the patients in material I, has not earlier been reported as an entity in RA, so no comparisons with previous reports can be made.

A subaxial lateral dislocation was not found in this investigation and appears only to have been reported earlier in a previous investigation with CT examinations (61), but the incidence is not settled.

The age of the present patients with cervical RA and dislocations is in agreement with earlier reports (50, 54, 55, 76, 116, 130), as is the female preponderance (84, 93, 116) and the mean duration of RA in vertical (50, 54, 130) or in subaxial dislocation (89, 116).

In patients with a subaxial antero-posterior dislocation, the findings of 31% with a progression is in accordance with a previous report (137). Only 1 patient (2%) in the present study was improved at the follow-up examination, but improvement was found by Smith et al. (116) in half of their patients, an astonishingly high figure. Their criterion for improvement was not given, and perhaps bony bridging was regarded as improvement. The same investigation (116) reported recovery from anterior atlanto-ax-

ial dislocation in 15% of their patients, but the radiographs of an example makes it clear that a transformation of the horizontal dislocation into a vertical dislocation was regarded as a recovery. Also deCarvalho and Graudal (32) found recovery in 3 cases due to a transformation of the horizontal dislocation into a vertical one. But this investigation, in accordance with most others (19, 77, 93), does not regard such a transformation as an improvement or a recovery, but rather as a progression of the disease.

The vertical, as well as the atlanto-occipital, dislocation is usually a late state of cervical arthritis. These dislocations are preceded by a horizontal atlanto-axial dislocation. The occipitoatlanto-axial joints are orientated in the horizontal plane and with an arthritic destruction of these joints and surrounding ligaments, an atlanto-occipital dislocation may appear. But the arthritic process may also precede and thus the atlas can sink down on the axis with concomitant erosive lesions of the former parts of the atlas and axis, giving a vertical dislocation. At the same time, the horizontal dislocation may usually diminish or disappear.

A predisposing anomaly has been suggested to be responsible for the dislocation in some previous reports on posterior atlanto-axial dislocation (40, 59, 122, 131) or atlanto-occipital dislocation (127), but in the previous cases radiographs have not been available before onset of disease. In the present study it is shown that a posterior atlanto-axial or an atlanto-occipital dislocation may appear without predisposing congenital anomalies. Thus, the dislocation is dependent only on the arthritic destruction of joint capsules, ligaments, and erosive lesions of the occipitoatlanto-axial region.

It has been suggested that patients would be more liable to a cervico-occipital fusion (120). The results here indicate that the deterioration is due to the severe arthritic disease and not only to the postoperative state with a rigid upper cer-

vical spine.

An affection of the spinous process with a diminished height, probably caused by a Baastrup-like process (18), was found to correlate with the occurrence of a severe subaxial antero-posterior dislocation.

In malignant diseases a subaxial vertical dislocation may appear as a result of destruction of the vertebral body, and usually there will be no affection of the discs and posterior elements. In RA the process starts in the apophyseal joints and discs and first thereafter there will be lesions of the vertebral bodies. But the process is more insidious in RA than in traumatic cases, in which there are more severe and nearly always permanent symptoms. Thus, in RA the spinal cord may have a chance to adapt itself to the diminishing space with usually no or only minor neurological disturbances.

Neurological disturbances have previously been regarded to be unpredictable but will often depend on the width of the cervical canal (19, 88). Neurological symptoms were significantly more common in patients with vertical or subaxial dislocations and a diminished sagittal diameter of the bony cervical spinal canal than in patients with a wide canal, but such symptoms also appeared in these latter patients. Most of these latter patients had an intracranially situated dens, which may have been impacting on the medulla, or a dislocation with encroachment at another cervical level. Meningeal rheumatoid granuloma may also cause neurological symptoms (53, 57) but this was not found in the present deceased patients in whom an autopsy was performed.

Neurological symptoms in patients with a subaxial antero-posterior dislocation occurred significantly more often in patients with a decreased height of the cervical spine, probably because the crosssectional area of the spinal cord increases with a diminished height of the cervical spine (11), and thus the cord will be more vulnerable to a diminished sagittal diameter of the bony canal.

One third of the patients were dead 3-10 years after the detection of vertical dislocation, and in 10% of the patients the vertical dislocation was found to be the main or a contributory cause of death. This high incidence of death is in agreement with an earlier investigation from the same two Malmö hospitals (87).

Dangerous situations for the patients seem to be general anaesthesia (90, 133), dental care (Paper II; 5) or lifting of the patients by the nursing staff (Paper V). Extensive neck movements by the patient may also cause an aggravation of a dislocation (Paper VI).

GENERAL SUMMARY AND CONCLUSIONS

A retrospective study was performed of 407 consecutive RA patients, who had had a cervical examination performed at the radiological department of Malmö General Hospital and Värnhem Hospital, also in Malmö, during the period 1978 through 1980.

Development of dislocations and their relationship with other arthritic changes were studied in these patients and in another 43 patients with cervical rheumatoid arthritis. Most of the patients with a dislocation were middle-aged or elderly women with a disease of long duration.

In this retrospective study, there were mostly only conventional radiographs available and measurements of vertical dislocation were impossible to carry out in several patients. A new measuring method was therefore designed for measuring the distance from the palato-occipital line to the lower end plate of the C2 vertebra. The normal lower limit of the distance was 34 mm in men and 29 mm in women. This new method was practicable in every case.

There were 43% of the patients with affection of the cervical spine. An anterior atlanto-axial dislocation was the most fre-

quent dislocation, appearing in 32%, followed by the subaxial anteroposterior dislocation (18%) and vertical atlanto-axial dislocation (10%). Rare dislocations were posterior atlanto-axial and subaxial vertical dislocation appearing in 1% and atlanto-occipital dislocation, in 0.5% of the patients.

There were no predisposing anomaly in cases with a posterior atlanto-axial or atlanto-occipital dislocation.

In patients with a severe anterior atlanto-axial dislocation the development of subaxial dislocation was the same in patients treated conservatively or by cervico-occipital fusion.

Sometimes the dislocation caused a narrowing of the bony cervical canal and when cord compression occurred neurological disturbances appeared, in single cases with paraparesis or death as the result.

The cervical examination must include lateral radiographs of the whole cervical spine, in both flexion and extension. The radiologist should not only search for dislocations but also for threatening encroachment on the spinal canal.

The new method, presented by the author, may be a helpful tool to measure a vertical atlanto-axial dislocation and thus to discover some of the patients in whom there is a need of more accurate examinations, such as CT.

CT gives good information about both the bony cervical canal and the central nervous system and it should be the method of choice in examinations of patients with advanced RA changes of the upper cervical spine.

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RADIOGRAPHIC MEASUREMENTS OF THE CRANIOVERTEBRAL REGION,
DESIGNED FOR EVALUATION OF ABNORMALITIES
IN RHEUMATOID ARTHRITIS.

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Since the initial report by DAVIS & MARKLEY (1951) concerning the fatal atlanto-axial dislocation in rheumatoid arthritis (RA), there has been an increasing interest in the radiology of alterations of the cervical spine in this disease. Initially, the interest focused on the anterior atlanto-axial dislocation (CONLON et coll. 1966, MEIKLE & WILKINSON 1971), but in the subsequent years there have been several reports on the hazards of a vertical dislocation (upward migration of the dens/cranial settling/atlando-axial impaction; SWINSON et coll. 1972, HENDERSON 1975). By the initial definition (McGREGOR 1948) such dislocation is present if the apex of the dens is situated more than 4.5 mm above a line drawn between the posterior margin of the hard palate and the most caudal part of the occiput (the palato-occipital or McGregor's line). In healthy individuals the apex of the dens is easily defined, but when there is vertical dislocation, there might be an overprojection of the mastoids on the dens in the lateral projection, making the identification of the dens difficult or impossible. Trials have been done to find other methods for measuring the vertical dislocation, more suitable in pathologic conditions, but hitherto no such method has proven sufficient.

The purpose of the present investigation was therefore to find a method in which vertical dislocation of the C1 and C2 vertebrae may be measured at conventional radiography in a normal material as well as in patients with rheumatoid arthritis, irrespective of the radiographic visibility of the apex of the dens. The purpose was also to find a possible correlation between the values obtained by this new method, with values obtained by the McGregor method.

The third purpose was to find normal measurement values for the McGregor method in a Scandinavian population of today, and to compare these with the values obtained by McGREGOR in Bantu Negroes.

MATERIAL AND METHODS

Material I ("normal marterial") consisted of consecutive examinations of the cervical spine in adults performed in 1980 at this hospital, because of pain, trauma, or possible metastatic lesions. Technically incomplete examinations (earrings covering the examination field or part of the cervical spine or the posterior part of the hard palate outside the field) were excluded as were examinations in patients with RA, and with collapsed vertebrae because of trauma or tumor.

The first 100 patients of each sex fulfilling these demands were reviewed. The distribution according to age and sex is given in Fig. 1.

Material II ("RA material") consisted of 61 patients, 10 men and 51 women, with RA who were examined at the same hospital during the period 1973-1980, and who had a vertical dislocation measurable according to the method proposed by MCGREGOR (a distance of more than 4.5 mm between the apex of the dens and the palatooccipital line). The distribution of this material according to age and sex is given in Fig.1.

All radiologic examinations had been performed with a standardized technique, with the patients erect and the head in a neutral position. The film-focus distance was 150 mm giving a linear magnification of 1.1. In the present investigation, the lateral projections were used.

In the lateral film, the palato-occipital line as defined was drawn. As a change of the perpendicular distance between that line and the center of the lower end plate of the vertebral body of the C2 is one expression of a vertical dislocation of the C1 and C2 vertebrae, this distance was measured (Fig.2). Also, the distance from the apex of the dens to the palato-occipital line according to MCGREGOR was recorded (Fig.2). For statistical analysis, linear regression and the Student's t-test was used. The measurements were performed with a ruler with a accuracy of

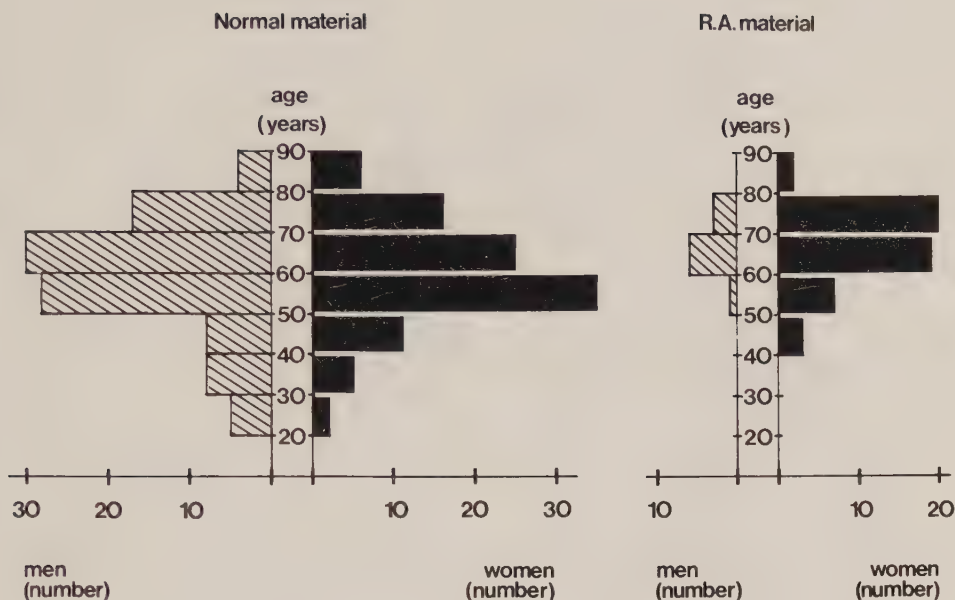


Fig. 1. Distribution according to age of 100 men and 100 women, comprising material I (normal material), and of 10 men and 51 women with rheumatoid arthritis comprising material II (RA-material)

$\pm 0.5\text{mm}$.

RESULTS

The distance between the lower end plate of the C2 vertebra and the McGregor line was possible to measure in all cases in both materials, as was the distance between the apex of the dens and the McGregor line.

The values obtained for the distance between the lower end plate of the C2 vertebra and the McGregor line are given in Table 1 and Fig. 3. In the normal material, there was no age diffe-

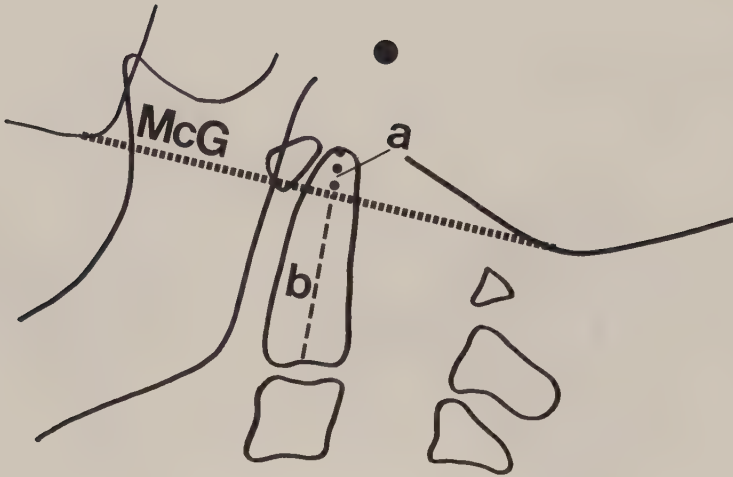


Fig. 2. Measurement method. McG = The palato-occipital or McGregor's line. a = the distance between the apex of the dens and McG. If the apex is situated below this line, the value will be negative. b = The distance between the lower end plate of the C2 and McG.

rence, but there was a statistically significant sex difference, the distance being greater in men than in women ($p < 0.001$). In men the distance ranges between 33.5 and 51 mm (mean 41.6 ± 4.0) and in women between 28 and 50 mm (mean 37.1 ± 4.3).

In the RA-material there was also a significant sex difference ($p < 0.05$). In both sexes, the values were significantly lower ($p < 0.001$), than in the normal material.

Table 2 and Fig.4 gives the values of the distance between the apex of the dens and the McGregor line. In the normal material the distance ranged between -5.0 and +9.5 mm in men (mean 2.4 ± 3.2 mm) and -7.0 and +9.0 mm in women (mean 2.5 ± 3.3 mm). There was no statistically significant sex or age difference. As is obvious from the selection of the RA-material the distance in this material was significantly larger than in the normal material of both sexes.

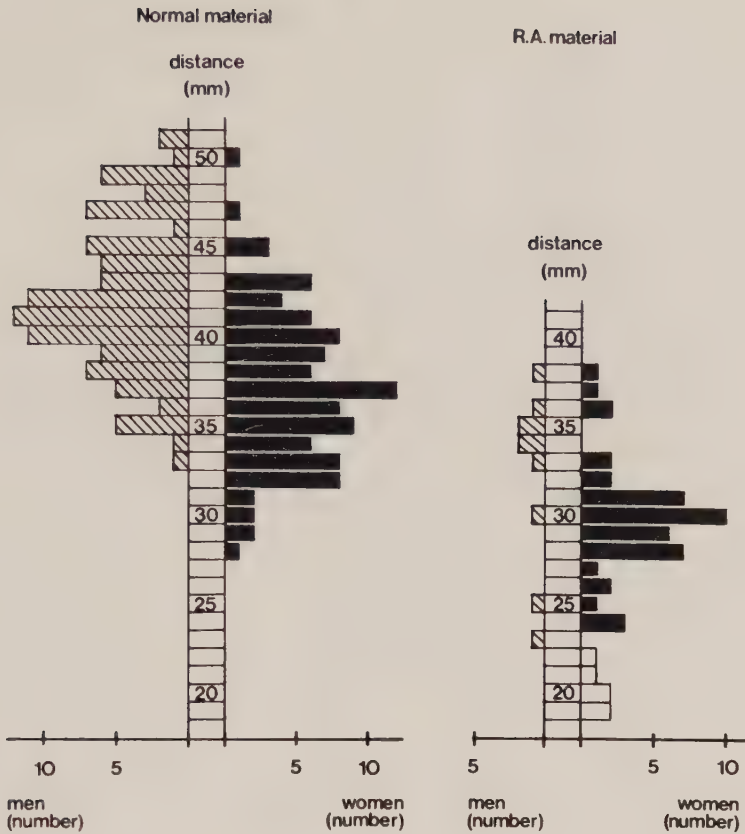


Fig. 3. Distance (mm) between the lower end plate of the C2 and McGregor's line according to sex.

The correlation between the distance (x) from McGregor's line to the lower end plate of the C2 vertebra and the distance (y) from that line to the apex of the dens is given for men in Fig. 5 a and for women in Fig. 5 b. The correlation coefficient of the combined material (material I and II together) was -0.784 for men and -0.921 for women. The corresponding figures for the normal material were -0.669 and -0.878 for men and women, respectively, and in the RA-material -0.829 for men and -0.794 for women. The regression line in the combined materials was calculated to be expressed by the formula $y=28.686-0.628x$ for men and $y=30.341-0.744x$ for women. The calculations of the regression line are valid for values of the distance between the McGregor's line and the lower end plate of the C2 of 25-51 mm in men and 19-50 mm in women.

Table 1.
Distance between McGregor's line and lower end plate of the
body of the C2 according to age and sex.

Sex	Age	Number	Distance between the end plate of C2 and McGregor's line (mm)
NORMAL MATERIAL			
Men	20-89	100	41.6±4.0
	(20-39)	(13)	(41.7±4.9)
	(70-89)	(21)	(41.7±4.3)
Women	20-89		37.1±4.3
	(20-39)	(7)	(39.6±4.3)
	(70-89)	(22)	(36.2±3.9)
RA MATERIAL			
Men	59-77	10	32.2±4.9
Women	43-80	51	28.7±4.3

Table 2.
Distance from McGregor's line to the apex of the
dens according to age and sex

Sex	Age	Number	Distance from apex of the dens to McGregor's line (mm)
NORMAL MATERIAL			
Men	20-89	100	2.4±3.2
	(20-39)	(13)	(1.8±3.5)
	(70-89)	(21)	(1.8±2.4)
Women	20-89	100	2.5±3.3
	(20-39)	(7)	(0.5±3.6)
	(70-89)	(22)	(3.0±3.4)
RA MATERIAL			
Men	59-77	10	10.2±3.3
Women	43-80	51	9.3±3.7

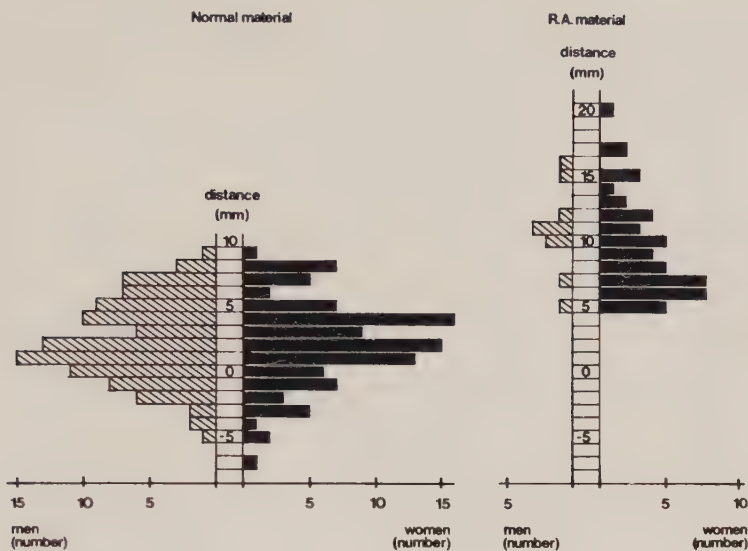


Fig. 4. Distance (mm) between the apex of the dens and McGregor's line according to sex.

DISCUSSION

Material I (normal material) was chosen to give normal values as a basis for further evaluation of cervical spine abnormalities in patients with RA and dysplasias. A true normal material, representing the entire population is not possible to achieve for ethical reasons, but excluding patients with arthritis and with vertebral collapse, the material should be appropriate to serve the purpose given.

Material II (RA-material) was selected in order to apply the method also in patients with vertical dislocation, and to evaluate the correlation between the values obtained with the new method and the McGregor method not only in normal individuals (material I) but also in patients with vertical dislocation (material II).

This vertical dislocation has been measured using several lines. Chamberlain's base line was drawn from the posterior bor-

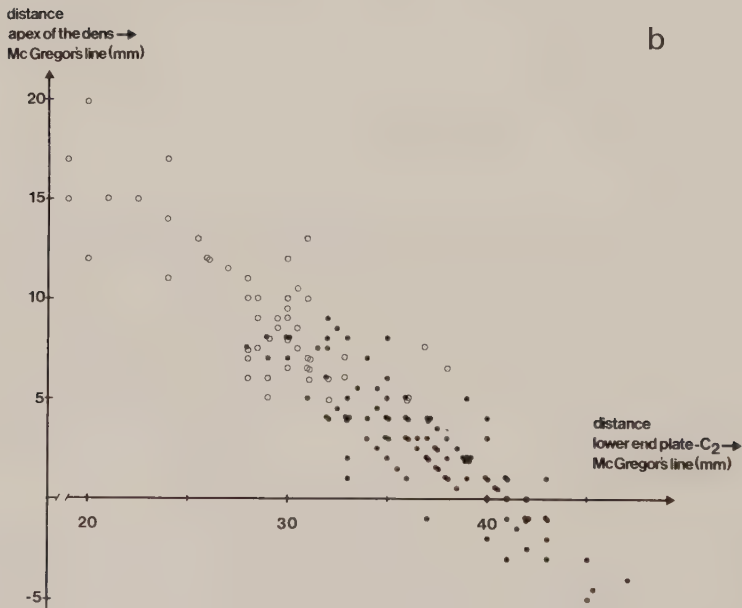
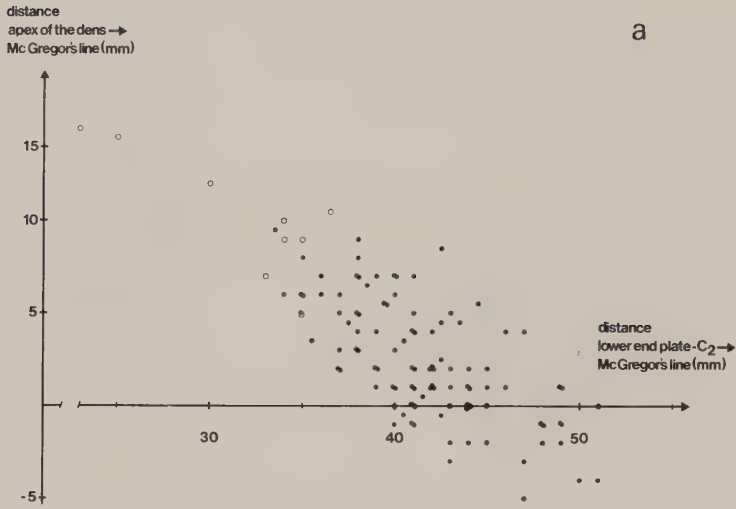


Fig. 5. The correlation between the distance from McGregor's line to the lower end plate of C₂ and the distance from that line to the apex of the dens in a: men and b: women from materials I (●) and II (○).

der of the hard palate to the posterior border of the foramen magnum (CHAMBERLAIN 1939) and the position of the odontoid in a normal material was given by SAUNDERS (1943). The posterior border of the foramen magnum may be impossible to define on the conventional lateral film so MCGREGOR suggested a line between the hard palate and the most caudad part of the occipital curve. Basilar invagination or vertical dislocation might also be measured using the foramen magnum line (McRAE 1953), the digastric line (FISCHGOLD et coll. 1959) or Bull's angle (BULL et coll. 1955). The foramen magnum line (McRAE) runs between the anterior and posterior margins of the foramen magnum but these margins may be difficult to define in patients with vertical dislocation. The digastric line (FISCHGOLD et coll.) connects the two digastric grooves as seen on an antero-posterior tomogram. The method proposed by BULL et coll. is more complicated because the angle between the line along the hard palate and the line drawn along the plane of the atlas must be measured. Besides that, it is valid only for patients in the prone position.

The McGregor line is usually easy to define even in cases with severe vertical dislocations and in most previous investigations the vertical dislocation in RA is measured using his line or not measured at all, but approximatively estimated.

The present method, as well as those earlier reported should act as a tool for evaluation of vertical dislocation of the C1 and C2 vertebrae in arthritis and dysplasia. In these pathologic conditions, an upward dislocation of the C2 and C1 vertebrae will give a large distance between McGregor's line and the apex of the dens while an erosion of the apex will minimize this distance. The dislocation and erosion often appear simultaneously in RA. The method of MCGREGOR defines the position of the apex of the dens, which is important from a clinical point of view as the dens may impact on the cervico-medullar region. However, as erosion of the apex of the dens and cranial dislocation of the C1-C2 complex are counteracting parameters, the values according to MCGREGOR obtained in patients with marked erosion of the dens will not accurately describe the cranial settling of the C1-C2

vertebrae. Also this dislocation might be clinically important as a marked cranial dislocation will shorten the upper part of the cervical spine, with ensuing impact on the cervical cord (DIRHEIMER & BABIN 1974, GOW & GIBSON 1977).

The present method, using the distance between the McGregor's line and the lower end plate of the C2 vertebra, is easily performed and has high accuracy. The measurement points are easily defined as arthritic destruction of the end plate of the C2 vertebra is extremely rare. It gives a direct measure of the total dislocation of the C1-C2 complex and as stated there is a good correlation between the values found by the present method and the method of MCGREGOR. This correlation may be expressed by the simplified formula $y=29-0.6x$ for men and $y=30-0.7x$ for women, where x denotes the distance from the lower end plate of the C2 vertebra to McGregor's line and y the distance from the apex of the dens to McGregor's line. For practical purposes, a distance between the lower endplate of the dens and the McGregor's line less than 34 mm in men and 29 mm in women (mean value -2 SD; Table I), is proposed to be defined as vertical dislocation. When such values are recorded, and the dens is not possible to identify at radiography, a conventional tomography or possibly also CT of the craniovertebral region should be performed. It is also obvious that other pathologic changes in the occipito-cervical region, such as horizontal dislocation of the axis and instability at flexion and extension is of utmost clinical importance and must be evaluated.

It is noteworthy that the normal values found are independent of age. Although degenerative changes are more common with increasing age, these changes are more marked in the lower cervical region than in the upper, and obviously degenerative changes in the C1-C2 region will not influence significantly on the joint space.

There are several aspects on the normal range of the distance between the apex of the dens and McGregor's line (MCGREGOR, ROHR 1956, MATHEWS 1969, BURWOOD & WATT 1974, WACKENHEIM 1974, TULSI

1978). The values found in the present investigation are in accordance with most of these earlier reports, although there is a tendency to slightly higher values than in the original work by MCGREGOR. This might be explained by racial difference, as MCGREGOR's population consisted of Bantu Negroes. In accordance with earlier reports, no sex or age differences were found. For practical purposes, it is proposed that when using the MCGREGOR method, a distance between the apex of the dens and McGregor's line exceeding 9 mm in both sexes (mean value $\pm 2SD$); Table 2), should be regarded as vertical dislocation. This is in accordance with the recently published report by WEISSMAN et coll (1982).

SUMMARY

A new method of measuring vertical dislocation of the C1 and C2 vertebra in rheumatoid arthritis is presented based on the distance from the lower end plate of C2 to the palato-occipital or McGregor's line. In a normal material the distance was found to be 34 mm or more in men and 29 mm or more in women. A value below these limits should be regarded as vertical dislocation. In the same normal material the value according to the McGregor method was found to be 9 mm or less in both sexes. In a combined material consisting of healthy individuals and patients with rheumatoid arthritis a good correlation between the two measurement methods was found. The new method has the advantage of giving a measurable value also in cases with advanced dislocations and an undiscernible dens, and of giving a correct value in cases with erosions and destruction of the dens.

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VERTICAL DISLOCATION OF THE C 1 AND C 2 VERTEBRAE IN
RHEUMATOID ARTHRITIS

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Vertical dislocation of the C1 and C2 vertebrae has drawn growing attention as an important part of the pathologic changes of the cervical spine in rheumatoid arthritis (EL-KHOURY et coll. 1980, HENDERSON 1975, MIKULOWSKI et coll. 1975, RASKER & COSH 1978, WEISSMAN et coll. 1982). Such dislocation has been said to exist when the top of the dens is located more than 4.5 mm (CABOT & BECKER 1978, HANCOCK 1978, MCGREGOR 1949), 7 mm (HJORT-JENSEN 1979) or 9 mm (REDLUND-JHONELL & PETERSSON 1983) above McGregor's palato-occipital line or when it is situated above the level of the foramen magnum (DIRHEIMER & BABIN 1974). Some authors have assessed the dislocation in a subjective way (SMITH et coll. 1972, WEISSMAN et coll. 1982), others have tried new measuring methods (RANAWAT et coll. 1979) but most reports use the original method of McGregor. However, the apex of the dens is not always possible to define at conventional radiography and recently we presented a simple method for evaluation of the vertical dislocation, based on measurements of the distance between McGregor's line and the lower end plate of the C2 vertebra (REDLUND-JHONELL & PETERSSON).

The incidence of the mentioned vertical dislocation in rheumatoid arthritis (RA) ranges widely (between 3 and 32%) in different materials (RASKER & COSH 1978, WINFIELD et coll. 1981). There is also some confusion as to the course of the dislocation and its relation to other arthritic changes of the cervical spine (HANCOCK 1978, MATHEWS 1974, WINFIELD et coll. 1981). The purpose of the present investigation was therefore to examine the frequency, severity and course of vertical dislocation of the C1 and C2 vertebrae, the relation between such dislocation and other arthritic changes of the cervical spine and its relation to age, sex, duration of disease and neurologic symptoms. The purpose was also to compare the availability of McGregor's method for assessing the dislocation with the availability of the new method presented by the present authors.

MATERIAL AND METHODS

During the period 1978 through 1980 there were 407 patients (96

men and 311 women) with RA who had a radiologic examination of the cervical spine at Malmö General Hospital and Värnhem Hospital, also in Malmö, covering a population of 230,000 inhabitants. Most of these patients had been examined as a routine before surgical intervention of any reason, or as routine control of the progression of the disease irrespectively of symptoms from the neck. About 20 patients were examined because of local symptoms. These 407 patients constitute material I and their distribution according to age and sex is given in Fig. 1.

In order to enlarge the material of pathologic cervical radiographs, all patients with RA who were not examined during the period mentioned, and who had a radiologic diagnosis of arthritis of the cervical spine at one of the hospitals during the period 1973 through 1977 were included. Thus 43 patients constituting material II were added. Their distribution as to age and sex is given in Fig. 1.

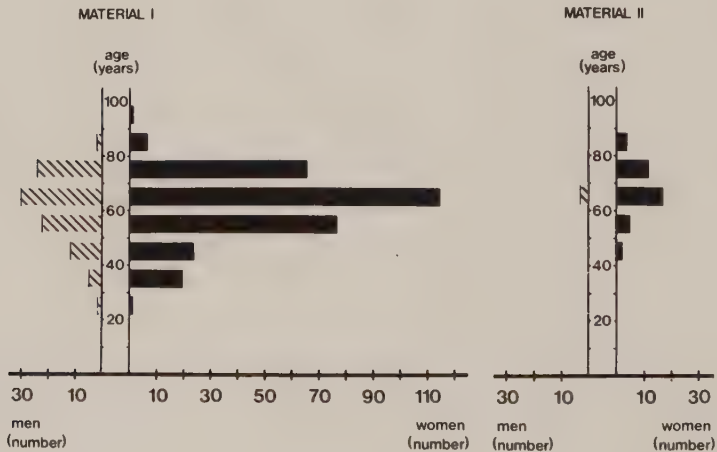


Fig. 1. Age and sex distribution of material I comprising 407 patients with RA who had a radiography of the cervical spine performed in 1978-1980, and of material II of another 43 patients with a radiography performed in 1973-1977.

For all patients all films had been preserved and all cervical films were reviewed for vertical and horizontal dislocation as well as for other arthritic changes of the cervical spine. If possible, vertical dislocation of the C1 and C2 vertebrae was measured according to MCGREGOR as well as to the new method introduced by REDLUND-JOHNELL & PETTERSSON. Using the McGregor method a distance between the apex of the dens and the palato-occipital line of 9 mm or more was regarded as a vertical dislocation (WEISSMAN et coll. 1982, REDLUND-JOHNELL & PETTERSSON) while using the authors' method a distance less than 34 mm in men and 29 mm in women between the center of the lower end plate of the C2 vertebra and the palato-occipital line was defined as vertical dislocation.

The measurements were performed on the lateral views with the cervical spine in neutral position, as a small vertical dislocation of the C1 and C2 vertebrae may disappear in flexion in patients with a coexisting (horizontal) anterior atlanto-axial dislocation. The severity of the dislocation according to age, sex and duration of the disease at the time of detection of the dislocation was analyzed as well as the relation between the vertical dislocation and other arthritic changes of the cervical spine. Horizontal dislocation was defined as a distance of more than 3 mm between the atlas and the anterior surface of the dens in flexion (HOLLANDER 1966). The sagittal diameter of the cervical spinal canal was measured at the level of C1 from the border of the dens/body of C2 to the posterior arch of the atlas and a distance of less than 13 mm was regarded as a narrowed spinal canal (WOLF et coll. 1956).

In all patients the charts were reviewed for neurologic disturbances. Occipital and cervical pain alone was not regarded as neurologic symptoms, but so were paresthesias, paresis, drop attacks and micturition disturbances. In the deceased patients the autopsy charts were studied.

In the statistics the χ^2 -test was used.

RESULTS

Comparison between the McGregor method and the new measurement method. Of the 407 patients in material I, the apex of the dens was possible to define in 378 patients and according to the McGregor method a vertical dislocation existed in 13. Of the 43 patients in material II the apex of the dens was possible to define in 30 patients and a vertical dislocation was found in 7 patients.

According to the new method vertical dislocation was possible to assess in all cases in both materials. Such dislocation was found in 42 patients in material I and in 20 patients in material II, giving a total of 62 in the combined material. From Table 1 it is evident that the possibility to use McGregor's method decreased with increasing dislocation. In the following, vertical dislocation will be expressed according to the new method.

Table 1.

Comparison between the possibility to assess the vertical dislocation with the two measurement methods in the total material and in patients with different degree of dislocation.

	Total material (n=450)	Patients with vertical dislocation as distance between McGregor's line and lower end plate of C2. (n=62)		
		men : ≤ 34 mm	≤ 29 mm	≤ 24 mm
		women: ≤ 29 mm	≤ 24 mm	≤ 19 mm
McGregor's method practicable	408 (90%)	19 (30%)	7 (21%)	0 (0%)
New method practicable	450 (100%)	62 (100%)	33 (100%)	18 (100%)

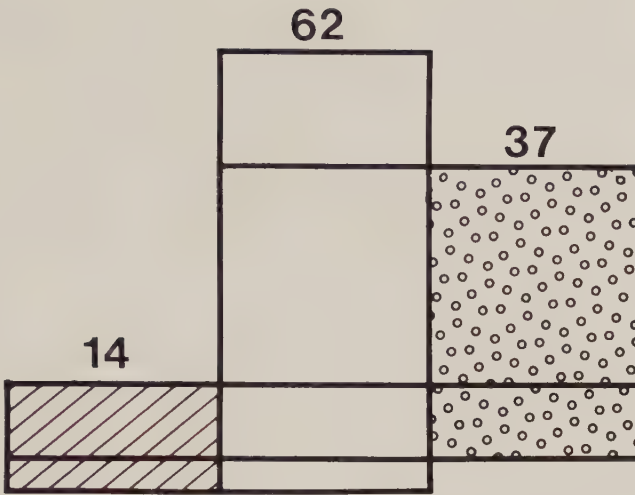


Fig. 2. Schedule of the 62 patients with vertical dislocation according to the existence of examinations performed before and after the detection of vertical dislocation. Fourteen patients with examinations performed before detection and 37 after detection.

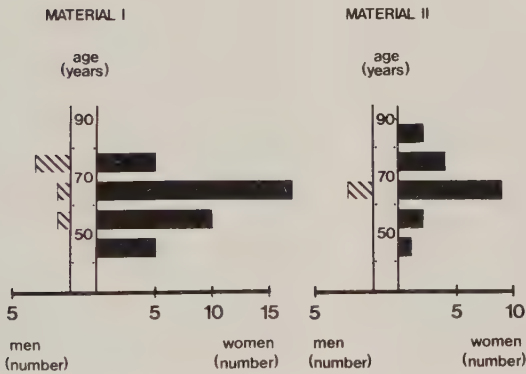


Fig. 3. Age and sex distribution of the 42 patients with vertical dislocation in material I and the 20 patients with vertical dislocation in material II.

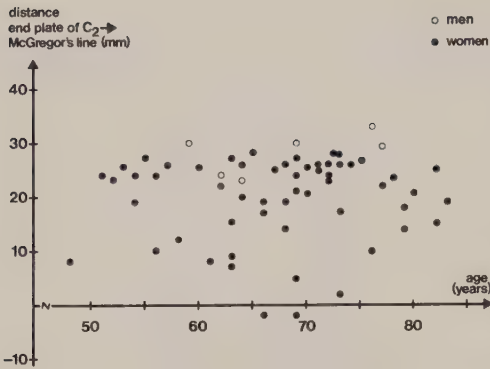


Fig. 4. Degree of vertical dislocation according to age and sex at the last performed examination of the 62 patients of the combined material.

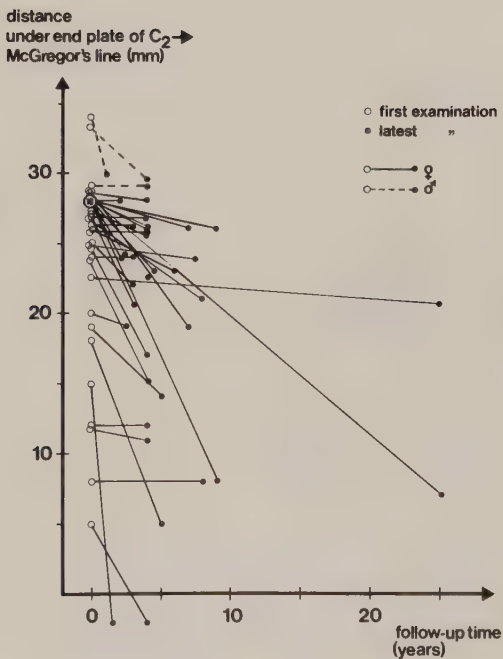


Fig. 5. The change in vertical dislocation according to time in the 37 follow-up patients.

The frequency and severity of the dislocation according to age, sex and duration of disease. As 177 patients in material I had signs of cervical arthritis, 42 patients with vertical dislocation means a frequency of 10% in the whole material I and of 24% in the patients with arthritic changes of the neck.

Among the 62 patients with vertical dislocation of the combined material there were some with cervical examinations performed before and/or after the detection of vertical dislocation. Fig. 2 gives a schedule of these patients. There were 14 patients with examinations performed before and 37 with examinations performed after the detection of vertical dislocation. These 37 patients are below referred to as follow-up patients. In all there were 245 cervical examinations of the 62 patients.

The distribution of pa-

tients according to sex and age at the detection of vertical dislocation is given in Fig. 3. The mean age of the patients was 63 years ranging 38 to 83 years. The degree of dislocation at the last available examination according to age and sex is given in Fig. 4. There was no age difference concerning the degree of dislocation. The duration of disease when a vertical dislocation was detected ranged 4 to 50 years, mean 21.9 years.

The course of vertical dislocation. The change of vertical dislocation in the 37 follow-up patients is given in Fig. 5. A progression was seen in 30 patients (81%) during the follow-up pe-

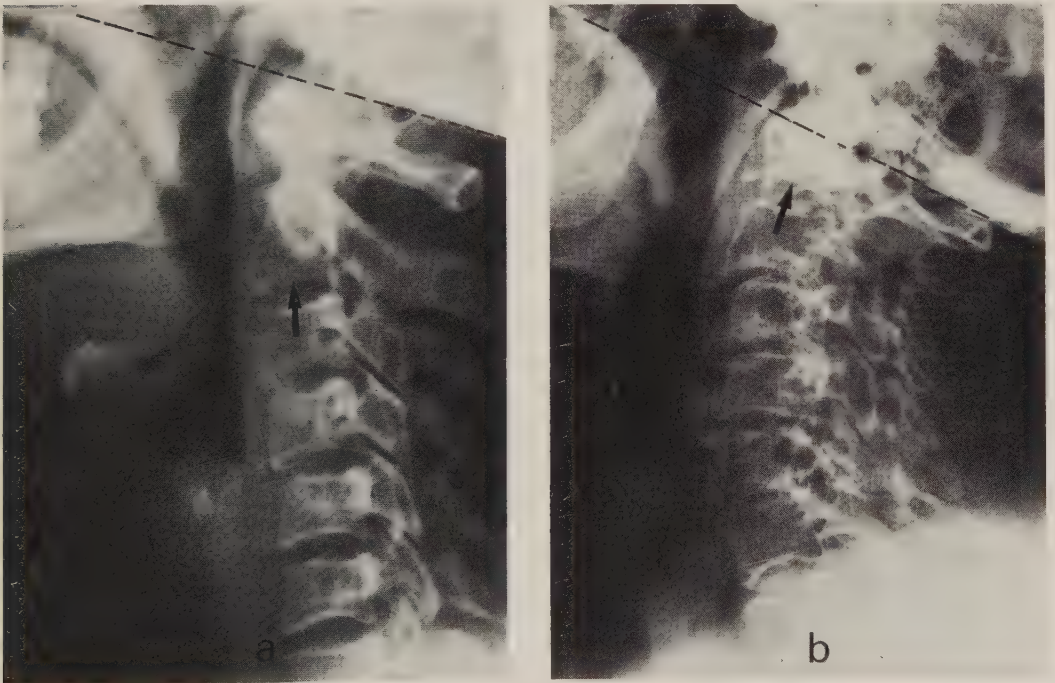


Fig. 6. The development of vertical dislocation. Dotted line denotes McGregor's line. a) Examination before appearance of any arthritic change. The dens is well defined and a vertical dislocation can be excluded by both method. b) 22 years later there is an advanced vertical dislocation and the apex of the dens is not possible to define. A vertical dislocation can only be measured according to the new method. Lower end plate of C2 (→).

riod, while 7 patients had no such progression. In no case did the vertical dislocation diminish or disappear after its appearance. There was no significant difference between the original mean values of vertical dislocation in the groups with or without progression. Neither was there any correlation with age as to the rate of progression. An example of the development of vertical dislocation is given in Fig. 6.

Relation between vertical dislocation and horizontal atlanto-axial dislocation. The degree of horizontal dislocation at the first and last examinations in the 37 follow-up patients and the coincidence of the two types of dislocation is given in Fig. 7. It is obvious that an increase in vertical dislocation was combined with a decrease in horizontal dislocation.

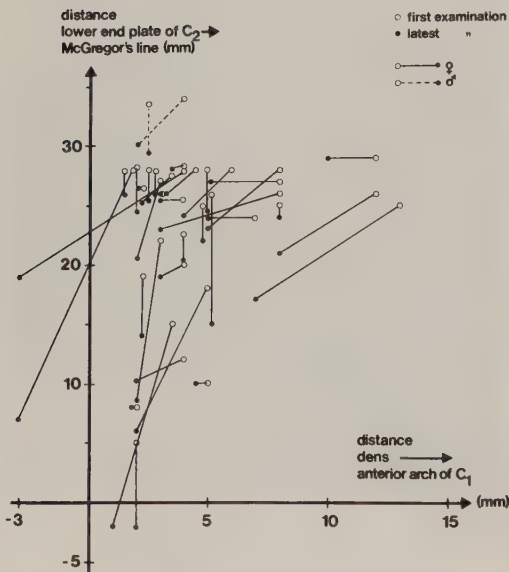


Fig. 7. The change in vertical dislocation being statistically significant in relation to a coincident change in horizontal dislocation in the 37 patients with a follow-up examination. ($p < 0.001$; Table 2).

Of the 14 patients who had no vertical dislocation at the first available examination, 13 had a horizontal dislocation at this earlier occasion. The outcome of this horizontal dislocation, when the vertical dislocation appeared, is given in Fig. 8 and it is obvious that in most cases the horizontal dislocation decreased or disappeared.

Relation between vertical dislocation and erosive lesions of the C1 and C2 vertebrae.

Erosive changes of the atlas were much more common in patients with advanced vertical dislocation, this difference in frequency

Table 3 gives the relation

Table 2.

Relation between erosive changes of the atlas and severity of vertical dislocation.

Vertical dislocation as distance between McGregor's line and lower end plate of C2.			
Mild dislocation		Severe dislocation	
Men	25 - 34 mm	Men	< 24 mm
Women	20 - 29 mm	Women	< 19 mm

No erosive changes of C1	32	4
Erosive chan- ges of C1	6	20

(p < 0.001)

Table 3.

Relation between erosive changes of the body of the C2 and severity of vertical dislocation.

Vertical dislocation as distance between McGregor's line and lower end plate of C2.			
Mild dislocation		Severe dislocation	
Men	25 - 34 mm	Men	< 24 mm
Women	20 - 29 mm	Women	< 19 mm

No erosive changes of C2	32	4
Erosive changes of C2	7	16

(p < 0.001)

between erosive lesions of the anterior part of the axis and the degree of vertical dislocation and again there was a statistically significant correlation between vertical dislocation and advanced vertical dislocation and the existence of erosive

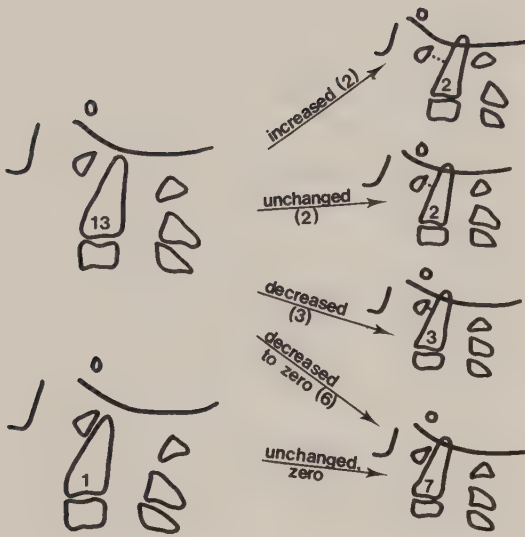


Fig. 8. The existence and course of horizontal dislocation and its change when a vertical dislocation appears in the 14 patients with earlier examinations.

changes of the axis ($p < 0.001$). In 3 patients with severe vertical dislocation it was not possible to assess the state of the body of the C2 and these patients were excluded. The statistical significance given is valid regardless of these 3 patients. A total destruction of the dens was seen in 5 patients and all these had an advanced dislocation.

Table 4.

Relation between degree of vertical dislocation and subaxial dislocation.

Vertical dislocation as distance between McGregor's line and lower end plate of C2.		
Mild dislocation		Severe dislocation
Men	25 - 34 mm	Men $\leq$ 24 mm
Women	20 - 29 mm	Women $\leq$ 19 mm
No subaxial dislocation	8	12
Subaxial dislocation	16	26

No significant difference.

Table 5.

Relation between neurologic symptoms and vertical dislocation in the patients of the combined material with arthritic changes of the neck (n=220).

	No neurologic symptoms	Neurologic symptoms
No vertical dislocation	151	7
Vertical dislocation	43	19
(p < 0.001)		

Relation between vertical dislocation and horizontal dislocations below C2 (subaxial dislocation). A subaxial dislocation of more than 2 mm was found in 42 patients (58%). The subaxial dislocation was as common among those with a mild vertical dislocation as among those with a severe dislocation as shown in Table 4.

Relation between vertical dislocation and neurologic symptoms. There were in all 220 patients with arthritic changes of

Table 6.

Relation between neurologic symptoms and degree of vertical dislocation. Vertical dislocation is expressed as distance from palato-occipital line to lower end plate of C2.

	Mild vertical dis- location, distance	Severe vertical dis- location, distance
	Men 25-34 mm Women 20-29 mm	Men $\leq$ 24 mm Women $\leq$ 19 mm
No neurologic symptoms	37	6
Neurologic symptoms	6	13

(p < 0.001)

the neck and the relation between neurologic symptoms and vertical dislocation among them is shown in Table 5. There were significantly more patients with neurologic symptoms among those with a vertical dislocation than among those without it ($p < 0.001$). The occurrence of neurologic symptoms in relation to the degree of vertical dislocation is shown in Table 6. Neurologic symptoms occurred significantly more often if the vertical dislocation was severe than if it was mild ($p < 0.001$). Most of the patients with neurologic symptoms had paresthesias, paresis or micturition disturbances while two of the patients had symptoms of vertebral ischaemia. The neurologic symptoms of the patients had usually been more or less insidious, but one patient became deteriorated after a tooth extraction.

Of the 62 patients with vertical dislocation 20 died during the period 1973 - 1980 or within 2 years afterwards. Autopsy was performed in 17 patients. The cervical spine was not examined in 4 patients. In 6 the cervical dislocation was regarded as a contributory or main cause of death and in the remaining 7 patients the dislocation was noted but there was no compression of the spinal cord.

Relation between narrowing of the spinal canal and neurologic symptoms. The measured sagittal diameter of the spinal canal had no correlation to the degree of vertical dislocation. Table

Table 7.

Relation between narrowing of the spinal canal and neurologic symptoms among the 62 patients with vertical dislocation.

	No narrowing of the spinal canal Sagittal diameter ≥ 13 mm	Narrowing of the spinal canal Sagittal diameter < 13 mm
No neurologic symptoms	41	2
Neurologic symptoms	12	7

($p < 0.001$)

7 gives the relation between a narrow spinal canal at C1 (sagittal diameter < 13 mm) and neurologic symptoms among patients with vertical dislocation. Neurologic disturbances were much more common among patients with a narrow canal than among those with a wide canal ($p < 0.001$).

DISCUSSION

Vertical dislocation of the C1 - C2 vertebrae, cranial settling, atlanto-axial impaction, upward translocation or upward dislocation of the dens is a decrease in the distance between the foramen magnum and the axis. Most authors have measured the dislocation according to the method of MCGREGOR but as shown in the present investigation this method is impossible to use at conventional radiography when there is an advanced vertical dislocation and the apex of the dens is not discernible. The present results show that the new measurement method, proposed by the authors, is superior to the McGregor method as it can be used in all cases. In comparison with the method of RANAWAT et coll. our method has the advantage of including abnormalities of the atlanto-occipital interval.

The exact position of the dens can be determined by conventional tomography or computed tomography and should be so in most patients with advanced changes, but also with the aid of these modalities the apparent value of vertical dislocation can be falsely too low. In some cases there may be erosive lesions with shortening of the dens which may be located less than 10 mm above McGregor's line in spite of a severe vertical dislocation. Our method measures the vertical dislocation independent of changes of the dens but may give falsely too low values when there are erosive changes of the end plate of the axis. However, such lesions are extremely rare.

The present investigation is retrospective and the materials may represent a selection. There might be an overrepresentation of patients with moderate and marked severity of the disease in

the material I and with pronounced severity in material II. Thus the frequency of vertical dislocation found (10%) is probably higher than the incidence in the total population of patients with RA.

Previous papers on vertical dislocation usually report only a few cases of vertical dislocation (EL-KHOURY et coll. 1980, HENDERSON 1975, MIKULOWSKI et coll. 1975), although some report about 20 to 40 cases (HANCOCK 1978, HJORT-JENSEN 1979, PELLICI et coll. 1981, RASKER & COSH 1978, WEISSMAN et coll. 1982). The present investigation seems to involve the hitherto greatest number of patients (62) and the frequency found, supposed to be higher than the true incidence, is yet lower than in most reports on record (CABOT & BECKER 1978, HANCOCK 1978, HJORT-JENSEN 1979, MATHEWS 1974).

The age of the patients is about the same here as in other reports of vertical dislocation (HANCOCK 1978, HENDERSON 1975, HJORT-JENSEN 1979, WEISSMAN et coll. 1982) as is the sex distribution with female preponderance (WEISSMAN et coll. 1982). At time of detection of vertical dislocation the duration of RA was about 22 years which is in accordance with previous investigations (HANCOCK 1978, HENDERSON 1975, WEISSMAN et coll. 1982). A vertical dislocation is thus not probable to occur in a patient with a short history. It should be noted though, that it is the time of detection that is reported and thus the true age and duration of disease at appearance of dislocation should be lower than the values found.

The vertical dislocation in most cases was progressive but neither the present investigation nor the literature have given any basis for prediction in the individual case.

In previous reports (HENDERSON 1975, MATHEWS 1974, WINFIELD et coll. 1981) the vertical dislocation was found in some cases to be preceded by a horizontal dislocation in accordance with this investigation where 13 of 14 patients with an earlier examination at that time had a horizontal dislocation. The transforma-

tion of a horizontal dislocation into a vertical, observed in the present study, should not be regarded as a spontaneous recovery (CABOT & BECKER 1978, MATHEWS 1974, PELLICI et coll. 1981). The cervical spine is said to be stabilized when this transformation occurs (PARK et coll. 1979) but to the expense of a progression of the arthritic changes.

Erosive lesions of the atlas and the dens are reported to exist in vertical dislocation (DIRHEIMER & BABIN 1974, EL-KHOURY et coll. 1980, HENDERSON 1975, PARK et coll. 1979). A certain collapse of the atlanto-occipital or atlanto-axial apophyseal joints must exist to make a vertical dislocation possible. With a further progression of the vertical dislocation the ring of the atlas settles down on the C2 and was found in the present investigation, as in a few earlier reports (EL-KHOURY et coll. 1980, PARK et coll. 1979) to erode the anterior and lateral parts of the body of the axis.

More than half of the patients had a contemporaneous subaxial dislocation reflecting that when a vertical dislocation appears there is usually a widespread arthritic affection of the cervical spine.

The sagittal diameter of the spinal canal of the C1 level had no correlation to the severity of vertical dislocation. The reason for this should be that a narrowing of the spinal canal is not only dependent on the degree of vertical dislocation but also on the co-existence of a horizontal dislocation. With unchanged horizontal dislocation during an increase of vertical dislocation the space of the spinal canal will diminish if not counteracted by erosive lesions of the axis. But, according to the present investigation, in most cases the horizontal dislocation diminishes or disappears during the progression of vertical dislocation, resulting in an unchanged or widened sagittal diameter.

The hazards of making neurologic examinations in crippled patients with severe arthritis of the peripheral joints is well

known (KATAOKA et coll. 1979, WEISSMAN et coll. 1982), diminishing the chance to correlate changes of the cervical spine with neurologic symptoms. Also, the common existence of a doctor's delay from the beginning of symptoms to the diagnosis of cervical myelopathy has recently been reported (MARKS & SHARP 1981). Thus, in the present retrospective material there might have been further patients with neurologic symptoms, not noted in the charts, giving a falsely too low frequency.

Injuries to the cervical spine may cause neurologic symptoms by bony pinching, a contact pressure, overstretching of the spinal cord, hematoma, circulatory disturbances and other miscellaneous factors (BRAAKMAN & PENNING 1971) and in RA the symptoms may be caused in the same way.

The diminished diameter of the cervical spinal canal is reported to be responsible for neurologic deterioration (CABOT & BECKER 1978) and in spinal stenosis at C1 neurologic symptoms were found in most patients (STEVENS et coll. 1971) which is in agreement with our results. Thus patients with advanced vertical dislocation and narrowing of the spinal canal at the C1 level should constitute a high risk group for neurologic disturbances. However, symptoms may be missing in spite of an apparently diminished sagittal diameter if there is a lateral dislocation of the C2. In this case the measured diameter gives a falsely too low value of the space for the spinal cord. On the other hand, symptoms may appear in patients with a wide spinal canal. This may be caused by rheumatoid granuloma of the meninges (HAUGE 1961), by the dens impacting on the medulla intracranially or by a dislocation at a lower level.

One third of the patients are now dead and this may reflect that vertical dislocation appears in elderly patients with an advanced general disease. However, in at least six of the 20 deceased patients the vertical dislocation was a main or contributory cause of death. This high incidence of death due to vertical dislocation is in accordance with an earlier autopsy report (MIKULOWSKI et coll. 1975).

CONCLUSION

The vertical dislocation of the C1 - C2 vertebrae in RA is a progressive condition with severe implications. Based on the present investigation we propose the following: when vertical dislocation is diagnosed its course initially should be controlled by a repeated radiologic examination in about half a year but in patients in an active phase of disease the control should be performed sooner. If no progression is observed a repeat examination a year is recommended, but when there are local symptoms from the neck or a deterioration of the rheumatoid disease a sooner control is recommended. With a rapid progression the patient perhaps should be offered an occipito-cervical fusion even if there are no neurologic symptoms. When such appear the arthritic changes may make surgical intervention a high risk.

SUMMARY

In a retrospective study of 450 patients with rheumatoid arthritis the cervical films were reviewed to detect vertical dislocation of the C1 and C2 vertebrae. A frequency of 10% was found among all patients and of 24% among those with cervical arthritis. The authors' method of measuring vertical dislocation at conventional radiography turned out to be superior to the method of McGregor, especially in cases with severe dislocation. The vertical dislocation was shown to be preceded by a horizontal dislocation and the appearance of vertical dislocation diminished or abolished the horizontal dislocation. Progression occurred in many cases and was combined with erosions of the atlas and axis. In more than half of the patients there was also contemporaneously a subaxial dislocation. Neurologic symptoms were more often occurring in patients with a severe vertical dislocation and in patients with spinal stenosis at the C1 level.

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POSTERIOR ATLANTO-AXIAL DISLOCATON IN
RHEUMATOID ARTHRITIS

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ABSTRACT

Seven patients with rheumatoid arthritis and posterior atlanto-axial dislocation are presented. The patients were elderly women with a disease of long duration. In all cases earlier cervical radiographs were available excluding any predisposing congenital anomaly. Fracture and/or arthritic destruction of the dens, of parts of the body of the axis or of the anterior arch of the atlas proved to be predisposing factors of the lesion.

INTRODUCTION

In rheumatoid arthritis (RA) several types of dislocation of the cervical vertebrae may occur. The most common type is the horizontal anterior atlanto-axial dislocation with an increased distance between the anterior arch of the atlas and the dens, that is found in up to 45% (Dirheimer 1977). A dislocation in the reverse direction, e.g., a posterior dislocation of the atlas means that the atlas with the occiput is dislocated backwards, with the anterior arch of the atlas located more or less above and behind the body of the C2, with an easily detected dislocation between the spinous processes. Such dislocation was reported earlier only as single cases (Teigland and Magnaes 1980, Verjaal and Harder 1965) until recently Weissman et al (1982) reported 13 cases among patients with rheumatoid affection of the cervical spine. A congenital anomaly predisposing for the dislocation has been supposed but in no reports earlier cervical radiographs of the patients have been available and the question of congenital predisposing factors is still unsettled.

The aim of the present investigation was to find the frequency of posterior dislocation of the atlas in a patient population of the southern Sweden and to explore its connection with other arthritic changes of the craniovertebral region and with possible congenital anomalies.

MATERIAL AND METHOD

During 1978 - 1980 407 patients with RA had cervical radiographs performed at Malmö General Hospital and Värnhem Hospital, also in Malmö. These patients constitute material I. Among those there were 177 patients with arthritis of the cervical spine.

To increase the material all RA patients with a cervical radiograph performed during 1973 to 1977, with a radiologic diagnosis of cervical arthritis and not belonging to material I were included. Thus another 43 patients were added, constituting material II.

All cervical radiographs of the 450 patients were reviewed for posterior atlanto-axial dislocation. In patients with this dislocation earlier radiographs, if any, were reviewed in order to possibly find a predisposing congenital anomaly. The charts were reviewed for neurological disturbances.

RESULTS

In material I there were 5 patients with a posterior disloca-

Table 1.

Distribution of arthritic changes in 7 female patients with posterior atlanto-axial dislocation.

Case	Age in year	Destruction of anterior arch of C1.	Fracture (F) or destruction (D) of dens.	Destruction of corpus of C2.
1.	76	-	F	-
2.	62	total	partial D	-
3.	66	-	total D	-
4.	63	-	partial D	partial
5.	78	partial	partial D	-
6.	73	partial	partial D	-
7.	56	-	partial D	-

tion of the atlas giving a frequency of 1.2% in the whole material or 2.8% among those with a cervical affection. In material II another 2 cases appeared. All these 7 patients were women. Their mean age were 68 years and the mean duration of disease was 17 years (range 4-35 years). The radiological findings of their upper cervical spines are presented in table I. In all cases there were radiographs available performed 1-23 years earlier and in no case there existed a congenital anomaly. Examples of radiographs from examinations before and after the development of a posterior dislocation are shown in Fig. 1 (case 2) and Fig. 2 (case 3).

In 3 of the patients the posterior dislocation was not fixed and thus in flexion it was restored and transformed into an anterior dislocation (Fig. 3; case 7). In none of these 3 patients a vertical dislocation of the C1 - C2 vertebrae was present but in 3 of the 4 cases with a fixed posterior dislocation there was also a vertical dislocation. There were some neurological symptoms only in these 3 cases but probably those symptoms were depending rather on the vertical dislocation than on the posterior dislocation. There was no development of encroachment on the spinal canal at the C1-C2 level, e.g., the sagittal diameter was not less than 13 mm. Most of the present patients had severe arthritic lesions of the whole cervical spine.

DISCUSSION

Traumatic backward dislocation of the atlas may be found with a fracture of the dens (Dangelmajer 1962) and very rarely without a fracture (Haralson and Boyd 1969). Atraumatic backward dislocation of the atlas is also reported in arthritic diseases and only single cases have been reported earlier (Crellin et al, Dirheimer 1977, Frigaard 1978, Hart et al 1981, Isdale and Corrigan 1970, Nakano 1975, Teigland and Magnaes 1980, Verjaal and Harder 1965, Weiner et al 1982, Weissman and Sosman 1975, Williams et al 1966) before the newly published study of Weissman et al (1982). In the earlier reports all the cases have had



Fig. 1. Case 2. a/ Lateral cervical radiograph with severe arthritic changes including a vertical dislocation.
b/ A year later there is a destruction of the anterior arch of the atlas and a posterior dislocation of the remains of C1.

Fig. 2. (Opposite side,above)
Case 3. a/ Lateral cervical radiograph from 1973 with a normal shape of the atlas and axis.
b/ Lateral radiograph from 1980 showing severe arthritic changes with a tiny posterior arch of the atlas dislocated backwards.

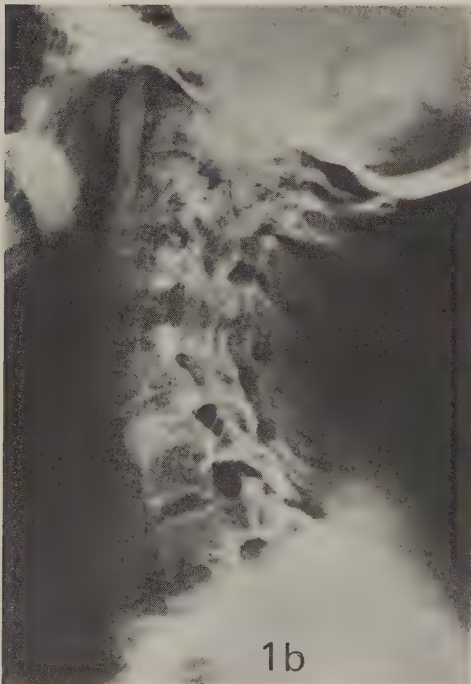


Fig. 3. (Opposite side,below)
Case 7. a/ Lateral cervical radiograph showing posterior dislocation in extension.
b/ In flexion there is an anterior atlanto-axial dislocation.



the body of the C2 situated below or in front of the anterior arch of the atlas, but according to the definition of Weissman et al, a posterior dislocation exists when the posterior aspects of the anterior arch of the atlas is posterior to the anterior border of the body of the C2. Their more extensive definition will probably explain that they found such a high incidence (6,7%). Using the same extended definition the frequency in the present investigation (2.8 %) was not statistically significantly different.

Case number 1 - 4 were more severe, resembling the earlier reported cases, with an easily detected dislocation of the spinous processes (Crellin et al 1970, Dirheimer 1977, Frigaard 1978, Hart et al 1982, Isdale and Corrigan 1970, Teigland and Magnaes 1980, Verjaal and Harder 1965, Weiner et al 1982, Williams et al 1966) while the other three have been included only according to the new definition of Weissman et al.

The female preponderance, the age of the patients and the duration of disease agree with earlier reports (Frigaard 1978, Isdale and Corrigan 1970, Teigland and Magnaes 1980, Weissman et al 1982, Williams et al 1966).

A predisposing congenital anomaly as an absence of the dens and/or of the anterior arch of the atlas was suggested as a possibility in the previous reports without earlier cervical radiographs available (Frigaard 1978, Isdale and Corrigan 1970, Verjaal and Harder 1965). In all the present cases there were earlier examinations preserved and they were normal with regard to the state of the dens and of the anterior arch of the atlas. Thus arthritic destruction seems to be the main cause of the dislocation, and was probably so also in the earlier reported cases.

Arthritic changes, that may make it possible for arthritic posterior dislocation to appear, is reported to be a fracture or a destruction of the dens and/or a destruction of the anterior arch of the atlas (Frigaard 1978, Isdale and Corrigan 1970, Ver-

jaal and Harder 1965). Such changes were also found in the here presented cases. To these conditions can be added a bone resorption of the anterior parts of the body of the axis, together with a vertical dislocation as in case 4.

The posterior dislocation has in some patients been found to be worse in cervical extension and less in flexion (Dirheimer 1977, Frigaard 1978, Isdale and Corrigan 1970), thus contrary to the anterior dislocation. This condition was also found in three of the present patients and in these an anterior dislocation appeared in flexion.

It is difficult to assess the prognosis for the patient with a posterior dislocation. In only one earlier reported case severe neurological symptoms due to the posterior dislocation were noted (Teigland and Magnaes 1980). It seems probable that a posterior dislocation should not be more dangerous than an anterior dislocation and, as in anterior dislocation, it is not the dislocation measured in mm that is important but the space left for the spinal cord.

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ATLANTO-OCCIPITAL DISLOCATON IN RHEUMATOID ARTHRITIS

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Dislocations within the cervical spine is common in rheumatoid arthritis (RA). The most common type is the horizontal atlanto-axial dislocation occurring in up to 45% (DIRHEIMER 1977) followed by the subaxial dislocation with an incidence of up to 41% (KATAOKA et coll. 1979). Slightly less common is the vertical dislocation of the C1 and C2 vertebrae reported to occur in 18% (MATHEWS 1974). Lateral dislocation may occur both in the vertical and horizontal dislocation and its incidence is reported to be 20% in patients with atlanto-axial dislocation (WEISSMAN et coll. 1982). Posterior dislocation of the atlas with regard to the axis is rare, only about 10 cases were reported before a recent study with about 25 cases (WEISSMAN et coll. 1982). Horizontal atlanto-occipital dislocation is very rare. Only 3 cases are on record (COSTE et coll. 1952, NAKANO et coll. 1978, WALCHER et coll. 1968) and the cause of the lesion is not known.

An atlanto-occipital dislocation may exist as a posterior dislocation of the occiput, which means that the posterior arch of the atlas is located in front of the posterior border of the foramen magnum. It may also appear as a forward dislocation of the occiput with the anterior arch of the atlas situated behind the anterior edge of the foramen magnum.

The aim of the present investigation was to find the frequency and type of atlanto-occipital dislocation of RA in a patient population of southern Sweden and to find any preceding or contemporaneous changes of the cervical spine.

MATERIAL AND METHOD

During the period 1978 through 1980 407 patients with RA had cervical examinations performed at Malmö General Hospital and Värnhem Hospital, also in Malmö, serving a population of about 230,000 inhabitants. These 407 patients constitute material I, and in this material 177 patients had arthritic changes of the cervical spine. In order to increase the material the cervical radiographs from 1973 through 1977 with a radiologic diagnosis

of cervical arthritis were included. Thus another 43 patients were found, constituting material II.

The cervical radiographs had in most cases been performed as a preoperative control but in some cases because of pain or neurologic symptoms or as a control of a known dislocation.

In the present investigation all patients with atlanto-occipital dislocation (as defined above) were searched for and all cervical radiographs of these patients as well as their clinical charts were reviewed.

RESULTS

In material I there were 2 patients (cases 1 and 2), and in material II 2 patients (cases 3 and 4) with an atlanto-occipital dislocation. Case number 4 had an anterior dislocation of the occiput but the other three had a dislocation in the reverse direction. All 4 patients had also vertical atlanto-axial dislocation and subaxial dislocation.

CASE REPORTS

Case 1. A 62-year old woman with RA since 35 years. A cervical radiograph from 1959 showed no arthritic changes. She had a mutilating RA and according to her own wish the treatment had only been acetylsalicylic acid and vegetarian food during the last 20 years. She was admitted to the hospital in 1979 because of difficulties in micturition and an increasing weakness of the arms and legs since 2 weeks. A cervical radiograph showed among other arthritic changes also an atlanto-occipital dislocation (Fig. 1 a and b). She was referred to a neurosurgical clinic where she was treated with skull traction and the symptoms subsided. At surgery ten days later a laminectomy of the atlas and a cervico-occipital fusion was performed, but her symptoms reappeared 1 week later and a new cervical radiograph showed re-

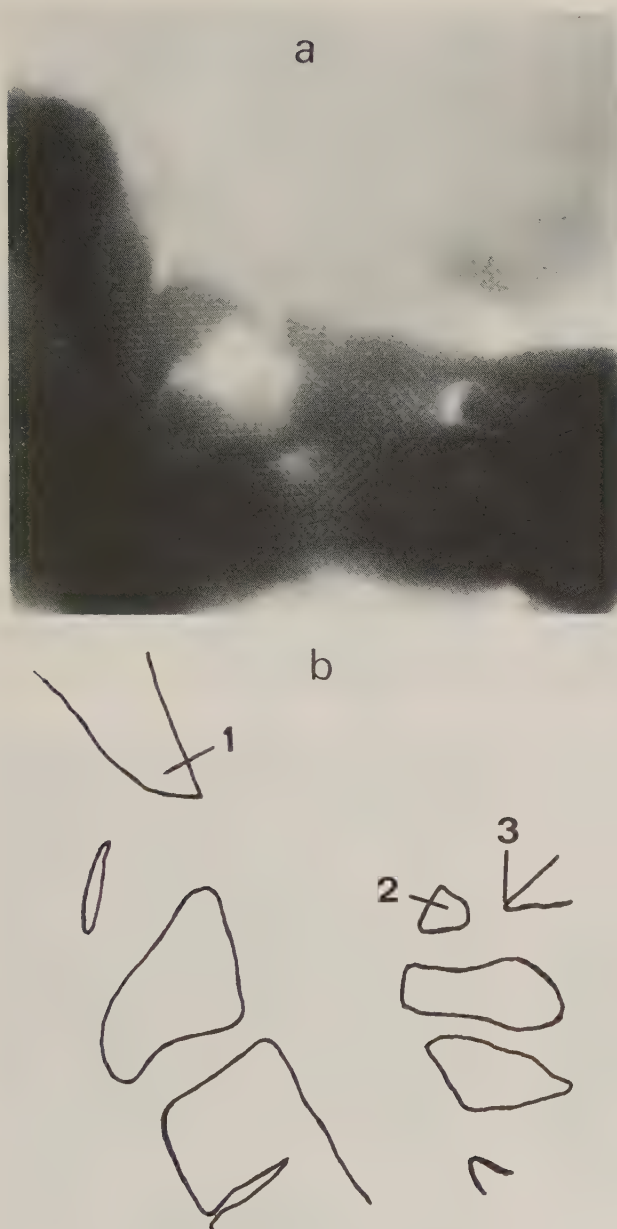


Fig. 1. Case 1. a) Lateral cervical tomogram from 1979. Atlanto-occipital dislocation with the posterior arch of the atlas in front of the posterior border of the foramen magnum. A skull traction is applied. b) A drawing of the radiograph above. 1 = clivus, 2 = posterior arch of the atlas, 3 = the posterior border of the foramen magnum.

appearance of the dislocations. Although no further treatment was instituted the severity of the symptoms gradually diminished. The patient died from lymphoma two years later.

Case 2. A 63-year old woman with RA since 16 years. A cervical radiograph performed in 1964, two years before the initial symptoms of RA, was normal (Fig. 2 a). A cervical radiograph from 1973 showed horizontal atlanto-axial dislocation which at an examination 3 years later was replaced by a vertical dislocation of the C1 - C2 vertebrae (Fig. 2 b). Despite several joint operations she could no longer manage at home and in 1979 she was admitted to the long-term medical care. At that time there were no specific neurologic symptoms. A cervical radiograph showed a diminished distance from the hard palate to the anterior arch of

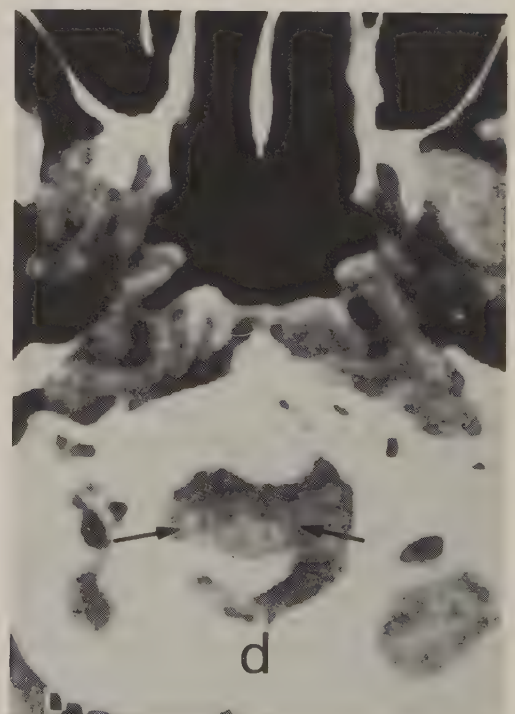
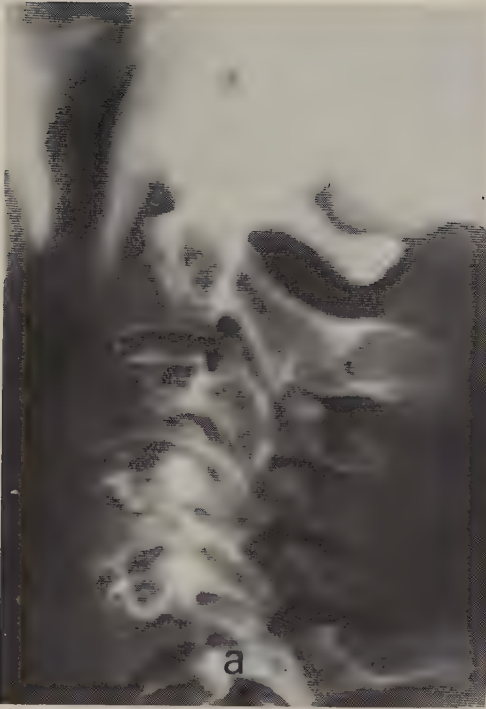


Fig. 2. Case 2. a/Lateral radiograph of the cervical spine from 1964, 2 years before appearance of RA. b/Lateral cervical radiograph from 1974 with an anterior atlanto-axial and a vertical dislocation. c/Radiograph from 1979 with a diminished distance from the hard palate to the anterior arch of the atlas (compared with earlier radiographs as measured after correction for magnification). The posterior arch is at the level of foramen magnum. The vertical dislocation has preceded. d/Computed tomography of the foramen magnum level from 1983. Arrows marks the medulla oblongata interposed between the dens and the posterior arch of the atlas, situated in front of the posterior border of the foramen magnum.

the atlas, indicating an atlanto-occipital dislocation (Fig 2 c). The exact position of the foramen magnum was difficult to state. There was also progression of other arthritic changes of the cervical spine. Three and half a years later she got paresthesias of the arms, difficulties in lifting them and sensibility disturbances. The conventional cervical radiograph was difficult to analyze but computed tomography revealed the posterior arch of the atlas to be situated in front of the foramen magnum (Fig. 2 d). She was referred to a neurosurgical clinic where a laminectomy of the C1 vertebra and a cervico-occipital fusion was performed with successful results.

Case 3. A 68-year old woman with RA since about 30 years. She had mutilating changes of the joints but had earlier not been hospitalized when she in 1977 was referred to the rheumatological clinic because of inability to walk and to lift her arms. She had numbness and paresthesias in the arms and when turning her head she got severe pain in the neck. A cervical radiograph showed an atlanto-occipital dislocation together with other severe changes. She was referred to the neurosurgical clinic. Skull traction was tried, but this did not relieve the symptoms, nor did it diminish the dislocation, so it was removed. Two days later she suddenly got unconscious and had no spontaneous breathing. After resuscitation attempts she regained heart action and was treated in respirator. She never regained consciousness and died 2 weeks later from pneumonia.

Case 4. A 63-year old woman with RA since 25 years. She had a mutilating RA and was confined to a wheel-chair. As a pre-operative control her cervical spine was examined. The cervical radiograph revealed a vertical atlanto-axial dislocation. She then became an inpatient at the longterm medical care and because of cervical pain a new examination was performed a year later. Among other arthritic changes there was also an atlanto-occipital dislocation with the posterior arch of the atlas situated behind the foramen magnum. She was admitted to a neurosurgical clinic but she refused an operation. The disease preceded and she got difficulties in swallowing and became incontinent. She died and at autopsy there was found an compression on the medulla oblongata.

DISCUSSION

The occipito-atlantal joints consist of two diarthrodial joints between the condyles of the occiput and the upper articular processes of the atlas. These joints are oriented in the horizontal plane and when a destruction of the capsule and the ligaments appears, there will be possibilities for backward or forward sliding of the occiput. This dislocation is not an isolated lesion but a part of an extensive mutilating RA of the craniovertebral region, as shown in the present cases.

It has been discussed if there might exist a congenital anomaly which will predispose to this type of dislocation (Walcher et al 1968) but in previously reported cases no earlier performed radiographs have been available. In three of the present patients earlier performed cervical radiographs were normal, and thus the arthritic destruction of capsule and ligaments should be sufficient as an explanation of the lesions.

Atlanto-occipital dislocation with the occiput anterior to the atlas has been reported in traumatic fatal cases (Alker et coll 1978), while backward dislocation of the occiput is reported in congenital anomalies of the craniovertebral junction (Coria et coll 1982) and in single patients with Mb Bechterew (Coste et

coll 1960, Martel and Page 1960). In the previous reports of 3 patients with RA (Coste et coll 1952, Nakano et coll 1978, Walcher et coll 1968) the occiput was dislocated backward as in three of the present patients. The dislocation caused by cervical arthritis thus seems to usually appear in the opposite direction to that caused by trauma.

The scanty of previously reported cases indicates a very low incidence of the lesion but the findings in the present investigation of two patients among 407, a frequency of $1/2$ %, and further two patients among 43 in material II suggests a higher incidence. The reason might be that the dislocation is not easy to discover at conventional radiography if not specially searched for, as exemplified by the present case no 3, where the diagnosis not was settled initally. With the aid of conventional tomography (Fig. 1 b) or computed tomography (Fig. 2 d) the diagnosis is easier obtained. For the crippled patient it is also easier to have computed tomography performed because the whole examination may be performed with the patient supine.

In the three earlier reported cases there were severe neurologic symptoms in one (Nakano et coll 1978), slight symptoms in one (Walcher et coll 1968) and no symptoms in one (Coste et coll 1952). The four present patients had severe neurologic symptoms but in two of the patients the symptoms did not appear until three years after the diagnosis of dislocation. It is impossible to judge if the symptoms were due to the atlanto-occipital dislocation or to the other present dislocations or to the combination of the dislocations. However, the radiologic diagnosis of atlanto-occipital dislocation in RA is a serious sign that always should lead to surgical consultation.

SUMMARY

Four cases of atlanto-occipital dislocation is described. Two of the cases were found in a material of 407 patients with RA, indicating a frequency of $1/2$ %. All the patients had severe

mutilating changes of the peripheral joints as well as of the cervical spine and all developed severe neurological symptoms. The diagnosis is not easy to set at conventional radiography so conventional tomography or rather computed tomography is recommended.

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SUBAXIAL ANTERO-POSTERIOR SUBLUXATION OF THE CERVICAL SPINE
IN RHEUMATOID ARTHRITIS.

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INTRODUCTION

In rheumatoid arthritis (RA) different types of dislocation of the cervical spine may occur and since the first reported fatal case in 1951 (1) these dislocations have attracted an increasing attention (2, 3, 4, 5, 6, 7, 8).

The most common and obvious type of dislocation is the anterior atlanto-axial dislocation and it is also the most studied (3, 5, 9). The second most common is the subaxial (serial or staircase) dislocation (3, 5, 9). This type of dislocation is a forward or backward dislocation of the cervical vertebrae below the C2 (10) usually combined with arthritic changes of the adjacent vertebral end plates.

The aim of the present investigation was to examine the frequency, severity and course of subaxial dislocation in RA and its relation to age, sex, duration of disease, neurological symptoms and to other arthritic changes of the cervical spine. The purpose was also to investigate if cervico-occipital fusion is promoting a development of subaxial dislocation.

MATERIAL AND METHODS

All consecutive cervical radiographs performed during the period 1978 through 1980 at Malmö General Hospital and Värnhem Hospital, also in Malmö, located in southern Sweden (population about 230,000) were reviewed. Among them there were 407 patients with RA, 96 men and 311 women and they constitute material I. Their mean age was 63 years (range 34-92 years). Among them there were 177 patients with changes compatible with RA of the cervical spine.

In order to enlarge the material of pathological cervical radiographs, all patients with RA who were not examined during the period mentioned above, and who had a radiological diagnosis of arthritis of the cervical spine at one of the hospitals

during the period 1973 through 1977 were included. Thus 43 patients constituting material II were added, 3 men and 40 women with a mean age of 68 years (range 47-84 years).

Most of these RA patients had been examined as a routine before surgical intervention of any cause, or as a control of the progression of the disease irrespectively of symptoms from the neck. About 20 patients were examined because of local symptoms.

All films of the patients have been preserved, and their cervical examinations from 1950 and later were reviewed for subaxial dislocations as well as for other arthritic changes.

The cervical examinations had been performed with a standard technique: the patient in an erect position and a film-focus distance of 150 cm. The laterals in flexion and extension were studied and all measurements were made directly on the film without correction for magnification.

A subaxial dislocation was said to exist if the distance between the posterior borders of two adjacent vertebral bodies was more than 2 mm (11) and a distance of 4 mm or more was defined as a severe dislocation. When there was a mobile dislocation the largest distance was recorded. A vertical dislocation of the C1 and C2 vertebrae was said to exist if the center of the lower end plate of C2 was located at a distance of less than 34 mm in men and 29 mm in women from the palato-occipital or McGregor's line (12). An anterior atlanto-axial dislocation was defined as a distance of >3 mm between the anterior arch of the atlas and the dens (6) and a distance of 8 mm or more was regarded as a severe dislocation.

All the patients who had been operated with a cervico-occipital fusion had had an anterior atlanto-axial dislocation of 8 mm or more. The development of subaxial dislocation in these patients was compared with that in patients with the same severe dislocation but with conservative treatment.

The occurrence of dislocation according to age, sex and duration of disease at the time of detection of subaxial dislocation was analyzed, as well as the course of the dislocation using available previous and later examinations. A bony bridge between the two dislocated vertebral bodies was not regarded as an improvement unless the dislocation was diminished.

The sagittal diameter of the spinal canal was measured at the level of dislocation directly on the film.

The height of the cervical spine from the skull base above the atlas to the lower end plate of the body of the C7 vertebra was measured in the neutral position. If the height had been reduced with at least 20 mm in comparison with an earlier examination it was regarded as a decreased height of the cervical spine, and if not, the height was regarded as preserved. This wide limit was chosen to exclude patients with apparent reduced cervical height caused by small changes in cervical flexion. In all cases with suspicion of diminished height there were earlier radiographs available.

Diminished height of the spinous process was regarded to exist if its height was at least 1 mm less in comparison with previous radiographs. Thus shortening of the process was not regarded.

The charts of the patients were reviewed for neurological disturbances such as paresthesias, paresis and micturition disturbances. In the deceased patients the autopsy charts were also studied.

In the statistics the X^2 -test was used.

RESULTS

The frequency and severity of subaxial dislocation according to age, sex and duration of disease. In material I there were 73 patients, 8 men and 64 women with a subaxial dislocation, which means a frequency of 18 % among all patients of that mate-

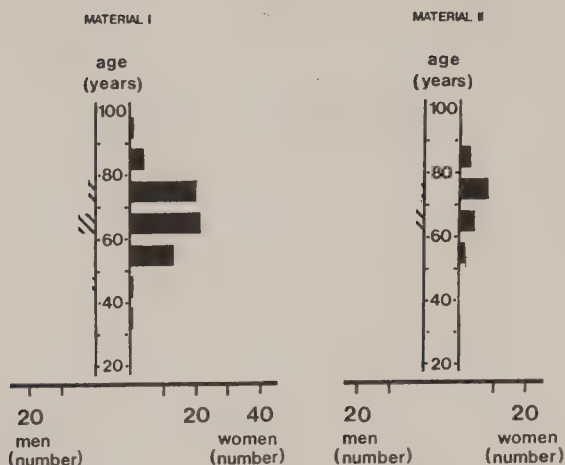


Fig. 1. Distribution of patients of material I and II with subaxial subluxation according to age and sex .

rial, and a frequency of 41% among those with arthritic changes of the cervical spine. The mean age was 65 years (range 34-92).

In material II there were further 21 patients with a subaxial dislocation (46%) with a mean age of 67 years (range 48-82). Altogether there were 93 patients in the combined material (11 men and 82 women). The two materials with subaxial dislocation are presented in Fig. 1. At the detection the mean duration of disease was 20 years (range 3-50 years) among the 82 patients with a known duration.

The distribution of dislocations at different cervical levels is given in Fig. 2. A dislocation at only one level was found in 48 patients (52%). A severe dislocation (4 mm or more) was found in 30 patients (30%) and 8 of those 30 had a severe dislocation at two or more levels. It was not possible to assess the state at the level of C7-Th1 in all cases due to technical shortages so the true number of dislocations at that level might be higher.

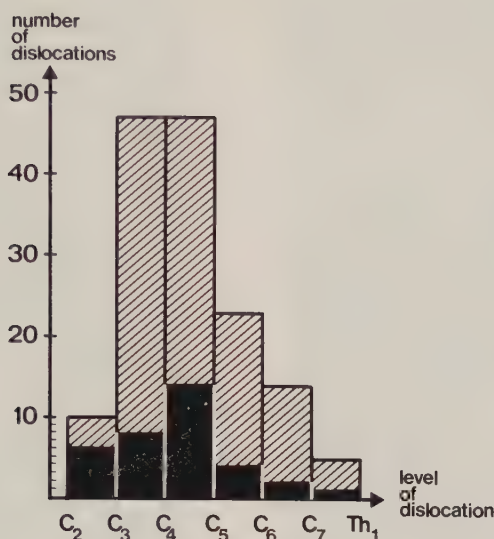


Fig. 2. Distribution of subluxations according to cervical level and severity of subluxations. Black area: severe subluxation (of 4 mm or more), dashed area: mild subluxation.

The course of subaxial dislocations. Among the 49 patients with an examination 2 years or more after the detection of dislocation there were 15 patients (31%) who had a progression while only one patient (2%) was improved. An example of the progression is given in Fig. 3.

Relation between subaxial dislocation and horizontal and/or vertical atlanto-axial dislocation. A pre-existing anterior or posterior atlanto-axial dislocation was found in 31 patients (33%) and a co-existing dislocation of that kind was found in another 37 patients (40%). Thus there were 27% of the patients without that dislocation.

There was a pre-existing vertical atlanto-axial dislocation in 18 patients (19%) and at the time of detection of subaxial dislocation further 31 patients (33%) had that dislocation.

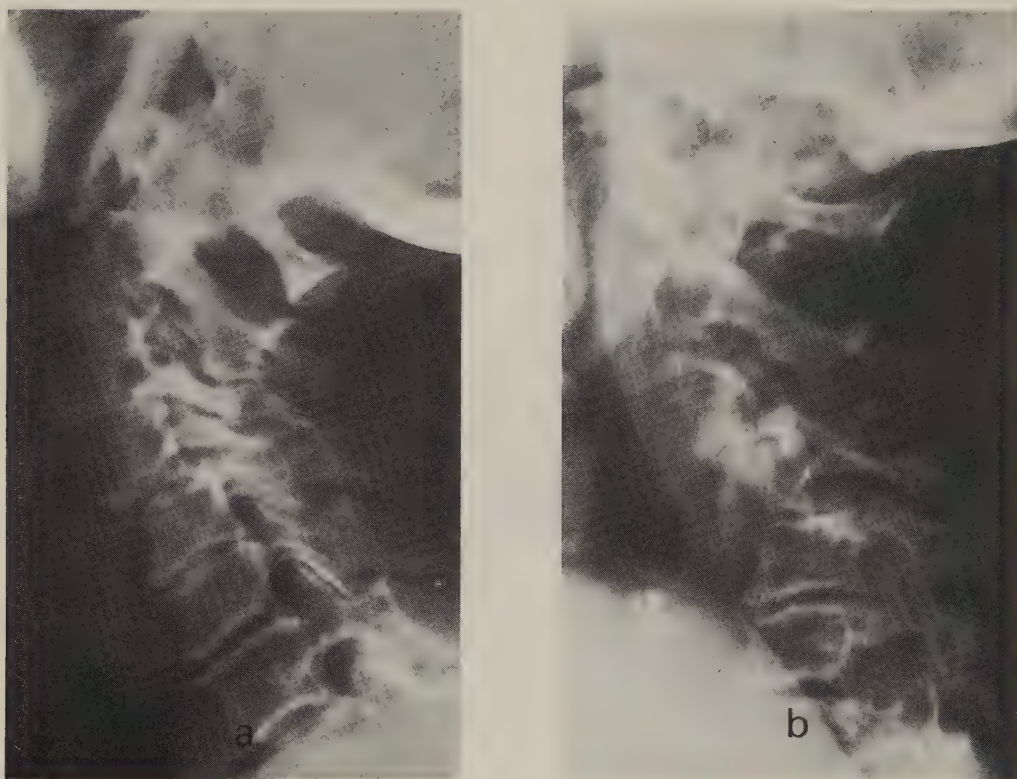


Fig. 3. Women born 1906. a) Lateral radiograph from 1976 with subluxations at C3 - C5. b) Lateral radiograph a year later showing deterioration. At the C4 - C5 level the subluxation is 8 mm and the sagittal diameter 12.5 mm. The patient had no neurological symptoms. There are only minor changes at the level of C1 - C2.

Neither horizontal nor vertical atlanto-axial dislocation was found in 10 patients (11%) but 4 of those had a severe subaxial dislocation. This dislocation was significantly more often occurring together with an atlanto-axial dislocation ($p < 0.001$; Table I) but the severity of subaxial dislocation was not correlated to the occurrence of atlanto-axial dislocation (Table I).

Relation between subaxial dislocation and severe atlantoaxial dislocation, treated conservatively or by cervico-occipital fusion. In the whole material there were 47 patients with an advanced anterior atlanto-axial dislocation (> 8 mm). Among 10 of them the symptoms had grown so severe that an operation with

Table I.

Relation between occurrence and severity of atlanto-axial subluxation and subaxial subluxation.

	No subaxial subluxation	Mild subaxial subluxation	Severe subaxial subluxation
No atlanto-axial subluxation	230	6	4
Atlanto-axial subluxation	127	61	22

cervico-occipital fusion had been performed. A follow-up examination after 2-9 years was available in 7 patients. In the group without operation examinations were available in 19 patients 1-8 years after the appearance of the advanced atlanto-axial dislocation. In Table II the development and deterioration of the subaxial dislocation in the two groups are compared. It is obvious that the cervico-occipital fusion did not promote development or aggravation of subaxial dislocation.

Table II.

Relation between occurrence or deterioration of subaxial subluxation in patients with severe anterior atlanto-axial subluxation treated conservatively or with cervico-occipital fusion at a follow-up examination 1 - 9 years later. No statistical difference was found.

	No or unchanged subaxial subluxation	New or deteriorated subaxial subluxation
Conservatively treated pat.	11	8
Fusion- operated pat.	4	3

Relation between subaxial dislocation and diminished height of spinous process. Subaxial dislocation was significantly more often occurring in patients with a diminished height of the spinous process ($p < 0,001$) than in patients with preserved heights (Table III). Affection of the spinous process was significantly more often occurring together with severe subaxial dislocation than with mild dislocation ($p < 0,001$; Table III).

Relation between degree of subaxial dislocation, sagittal diameter of the spinal canal and neurological symptoms. Neurological symptoms were noted in 20 patients. There was no connection between degree of dislocation and occurrence of neurological symptoms. However, the sagittal diameter of the spinal canal at the level of dislocation was less than 13 mm in 26 patients and there were significantly more patients with neurological disturbances among those with a narrow spinal canal (< 13 mm) than among those with a wide (≥ 13 mm; Table IV). Six of the 7 patients with neurological symptoms occurring in spite of a wide spinal canal (Table IV) had atlanto-axial dislocations with encroachment at that level, and the seventh patient had only minor symptoms (paresthesias in the arms).

Among the 13 patients with a narrow spinal canal and neurological symptoms there were both mild and severe disturbances.

Table III.

Relation between occurrence of subaxial subluxation and diminished height of the spinous process at the subluxation level.

	No subaxial subluxation	Mild subaxial subluxation	Severe subaxial subluxation
Preserved height of spinous process	350	50	10
Diminished height of spinous process	7	13	20



Fig. 4. Woman born 1899. a) Lateral hypopharyngeal radiograph from 1956 without arthritic changes but with a narrow spinal canal of 12.5 mm at the C3 - C4 level. b) Lateral radiograph from 1977 after the appearance of tetraparesis. The subluxation is only 3.5 mm, but this means a sagittal diameter of the spinal canal of 9 mm. There is also a vertical atlanto-axial subluxation.

Four patients had tetraparesis. Two of those got the symptoms suddenly when lifted by the nursing staff. One was treated with skull traction with relief of the symptoms. Therefore, a posterior fusion was performed, and the operation turned out successfully. The other patient had a dislocation of only 3.5 mm but a congenitally narrow canal (Fig. 4). She was in a poor general condition and no operation was performed. She died a year later and the autopsy revealed cord compression.

In at least 5 patients the neurological symptoms subsided without treatment. In patients with neurological symptoms the dislocation occurred as often in the upper as in the lower le-

Table IV.

Relation between neurological symptoms, sagittal diameter of the spinal canal and height of the cervical spine (between skull base and lower border of vertebral body of C7).

	Sagittal diameter 13 mm or more	Sagittal diameter < 13 mm
No neurological symptoms,		
all	60	13
with preserved height of cervical spine	50	10
with diminished height of cervical spine	10	3 *
Neurological symptoms,		
all	7	13
with preserved height of cervical spine	4	3 **
with diminished height of cervical spine	3	10

Each * denotes a patient with a narrow spinal canal at the C1 - C2 level.

vels of the subaxial part of the cervical spine.

Relation between height of the cervical spine and neurological symptoms. There were 13 patients with a decreased height of the cervical spine among the patients with subaxial dislocation. The relation between neurological symptoms and height of the cervical spine in the 26 patients with a narrow spinal canal is given in Table IV. There were significantly more patients with neurological disturbances among those with a decreased height than among those with a preserved height ($p < 0,001$).

DISCUSSION

Subaxial cervical dislocations may be seen in cervical spondylosis (11) and is then usually mild. In traumatic cases the dislocation may be mild or severe and even if the dislocation at the radiographic examination is slight it may have been worse at the moment of the accident. In RA the development of dislocation is insidious and the degree of dislocation may be at its hitherto maximum at the examination, provided that this includes laterals in flexion and extension.

In cervical spondylosis subaxial dislocation is said to be present if the dislocation is more than 2 mm (11). In RA the dislocation has been expressed as a percentage of the anteroposterior diameter of the upper end plate of the lower vertebra and Smith et al (13) regarded a dislocation of 15% cent as a significant displacement, corresponding to a dislocation of about 2 mm. The possible advantage of expressing the dislocation in % in comparison with absolute values in mm was not obvious in that study and therefore the dislocation here is reported in mm.

Some reports demand a dislocation at two or more levels for the definition of subaxial dislocation and use the terms "serial" or "stair-case" dislocation (2, 3, 9). The risk for including RA patients with a spondylotic dislocation (false positive) has then disappeared but on the same time patients with dislocation caused by RA will be excluded. However, most studies, as this, do accept a dislocation at only one level as an expression of rheumatoid affection (5, 6, 7, 8, 14, 15).

In earlier reports a frequency of subaxial dislocation of 6-41% has been found (3, 5, 7, 8, 13, 14) and our frequency of 18% is in agreement with these. The mean age of the patients, 65 years, is also in accordance with earlier reports (13) as is the preponderance of women (5, 7, 13) and the long duration of rheumatoid disease (9, 13). But in a newly published prospective investigation by Winfield et al (8) a frequency of 24% was found as early as within 5 years of disease onset. That investigation

had a criterion for dislocation of only 1 mm that would possibly explain the high incidence so early in the disease. Their incidence would be only 8 % with the same criterion for dislocation as in our study.

Subaxial dislocation is said to occur mostly in the middle part of the cervical spine in RA (5,6) and this investigation confirm that. But a severe dislocation may appear as high up as the C2-C3 level or as low as the C7-Th1 level.

The findings of about the same frequency of subaxial dislocation at one level as at two or more levels are in agreement with Winfield et al (8), as are the findings of a progression in 31% of the patients at a follow-up examination. In their investigation there was, as in most others, no report of any improvement, but in the present study that appeared in one patient. The only earlier investigation reporting of improvement in subaxial dislocation (13) noticed that in nearly half of the patients, an astonishingly high figure. Their criterion for improvement was not given and bony bridges might have been regarded as improvement.

In a previous prospective study, with early RA and a mean follow-up time of 7 years, a co- or pre-existing horizontal atlanto-axial dislocation is reported 17% (8). Another prospective study with patients in different states of disease and with a mean follow-up time of 6 years reports that in about 60% (7), and the latter study is more in agreement with this investigation (72%).

The coincidence of vertical atlanto-axial dislocation seems to have been studied in only one report earlier with a reported incidence of 12% (7). Our frequency is much higher (53%) which might depend on different methods of measuring the vertical dislocation (16).

It is noteworthy that in this material it was only 11% of the patients who had no atlanto-axial dislocation. The subaxial dis-

location will thus usually be preceded by an atlanto-axial dislocation or appear at the same time but a severe subaxial dislocation can yet be the first and only sign of cervical arthritis. Because of that the lateral films of the neck should include the whole cervical spine both in flexion and extension.

It has been suggested that patients after a cervico-occipital fusion will be more liable to injury of the rest of the cervical spine (16). The results here show that there is no difference in development of subaxial dislocations in patients with conservative treatment or cervico-occipital fusion.

There seems to be only single earlier investigations mentioning subaxial dislocation and its possible relations to changes of the spinous processes (4,6,15). One of them found no connection between shortage of spinous process and degree of dislocation (15) but no earlier report have correlated changes in height of the spinous processes to degree of subaxial dislocation. In the present investigation a severe dislocation was significantly more often occurring at a level with diminished height of the spinous process than at a level with preserved height. That might have been due to a Baastrup's syndrome (17) in combination with osteoporosis and/or interspinous RA, because bursae with arthritic changes have been found between the spinous processes in adult RA patients (18). Independent of the mechanism, resorption of the spinous process may indicate a severe dislocation.

Neurological symptoms secondary to rheumatoid arthritis of the cervical spine was first noticed in atlanto-axial dislocation (1) but it has also been reported in subaxial dislocations (4, 10, 14). Neurological disturbances is said to appear more often with a subaxial dislocation at a lower level where the spinal canal is smaller (2). Other investigators have reported that cord compression may be unpredictable but will often depend on the width of the cervical canal (19, 20). In spondylotic stenosis it is reported that with a sagittal measure of the spinal canal of 10-13 mm, cord compression may or may not be present

(21). In the present study the same measure of the spinal canal are combined with neurological symptoms in about half of the cases with RA and there were thus significantly more neurological symptoms among patients with a narrow spinal canal, than among those with a wide canal. There was only one patient with neurological symptoms who had no encroachment on the bony spinal canal at any level, but she had only minor symptoms (paresthesias of the arm), which are not unusual also in the spondylotic patient without cord compression (22).

The possible relation of a decreased height of the cervical spine to neurological symptoms seems not to have been investigated earlier in RA, but that a measurable decrease in height may appear is noticed (8). In a laboratory investigation with measurements of the cervical cord in flexion and extension it was shown that when the cord became shorter the cross-sectional area was increased, or in other words, the spinal cord adapted itself to varying length with plastic deformation (23). With a decreased height of the cervical spine the cross-sectioneal area of the spinal cord ought to increase, and thus be more vulnerable to a diminishing space of the spinal canal. This may explain our finding, that among patients with a narrowed canal, neurological symptoms were significantly more often occurring if there also was a decreased height of the cervical spine.

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SUBAXIAL VERTICAL DISLOCATION OF THE CERVICAL SPINE
IN RHEUMATOID ARTHRITIS.

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In rheumatoid arthritis (RA) of the cervical spine the most common dislocation is the horizontal anterior atlanto-axial dislocation (1, 2, 3). A few cases of posterior atlanto-axial dislocation are also reported (4, 5). Vertical atlanto-axial dislocation is not as common but is yet reported to occur in up to 22% among patients with cervical RA (6, 7). Lateral dislocation is also occurring at the atlanto-axial level (7, 8). Below the axis the dislocations are hitherto reported to be anterior or posterior dislocation (9), and this type of dislocation is the next most common in RA (10).

A vertical dislocation of the subaxial part of the cervical spine seems not to have been reported earlier in RA. Such a dislocation is here said to exist when the lower end plate of a vertebral body is dislocated to the same plane or lower than the upper end plate of the caudad vertebra. This dislocation should be associated with a certain amount of horizontal dislocation. A vertical dislocation with the C3 entering the atlas ring is considered to be an aggravation of the atlanto-occipital dislocation (6, 11) and is not regarded to be a vertical dislocation of the subaxial region.

The aim of this study was to investigate the frequency of this dislocation and to study how the lesion had developed.

MATERIAL AND METHOD

During the period of 1978 - 1980 407 patients with RA had cervical examinations performed at Malmö General Hospital and Värnhem Hospital, also in Malmö, in southern Sweden, serving a population of about 230,000 inhabitants. These 407 patients constitute material I. In this material 177 patients had arthritic changes of the cervical spine. In order to increase the material the cervical radiographs from 1973 through 1977 with a radiological diagnosis of cervical arthritis were included. Thus another 43 patients were found, constituting material II.

The radiographs were taken with a filmfocus distance of 150 cm and most often as a pre-operative routine examination and in some cases because of local symptoms. The examinations were reviewed in order to possibly find subaxial vertical dislocations.

The charts were reviewed for neurological symptoms and duration of disease.

RESULTS

In the 407 patients in material I 73 patients had a subaxial cervical antero-posterior horizontal dislocation of more than 2 mm (12) and among them 4 patients (1%) had a subaxial vertical dislocation. Among the remaining 334 patients in material I no one had a subaxial vertical dislocation. In material II 20 patients had subaxial horizontal dislocation and among them another 3 patients had subaxial vertical dislocation. All 7 patients had thus anterior or posterior subaxial dislocation at the same level. Bony fusion of the affected vertebral bodies was present in four patients. Two of the patients had subaxial vertical dislocation at two cervical levels (Table 1). One patient (case 1) had a considerably more pronounced dislocation than the others (cases 2 - 7). Below, case 1 is therefore reported separately while the findings in cases 2 - 7 are summarized.

CASE 1. A 49-year old woman with RA since 1959. During the first ten years the progression of the disease was fairly mild but then it became more active with mutilating changes in several joints of the body. Her first cervical radiograph was performed in 1971 because of pain and at that time there was a highpositioned atlas but no other arthritic changes (Fig. 1 a). In 1974 small subaxial horizontal antero-posterior dislocations, erosions of the spinous process of C7 and an aggravation of the vertical atlanto-axial dislocation were present (Fig. 1 b). In 1978 the dislocation at the C3 - C4 level had deteriorated with

a partial destruction of the two vertebral bodies (Fig. 1 c). In 1981 when flexing her head vigorously she suddenly got severe pain and paresthesias in the arms. The radiograph showed that the remnants of the C3 body had slipped forward and downward with regard to the C4 body, and that the spinous process of the C3 was located straight dorsally to the C4 body (Fig. 1 c).

The pain and paresthesias subsided, totally disappearing in 2 weeks, and has not reappeared in the elapsed one and half and a year. The only treatment has been a cervical collar.

CASES 2 - 7. All the patients were middleaged or elderly women with a mean duration of RA of 20 years. The dislocation varied between 2 and 12 mm and all levels between C3 and C7 were represented. The dislocation was preceded by atlanto-axial dislocation in 5 patients and in all it was preceded and combined with subaxial antero-posterior dislocation at the same level. The sagittal diameter of the spinal bony canal varied from 4 to 15 mm at the level of dislocation (Table I). Five of the 6 pa-

Table I.

Schedule of patients with subaxial vertical dislocation and of pathological findings of their cervical spines. The 4 first patients belong to material I, the others to material II.

Case number	Age at appearance (years)	Degree of dislocation (mm)	Level of dislocation	Width of spin.canal (mm)	Bony fusion	Neurol. symptoms
1	49	18 and 6	3-4 and 6-7	10 and 17	- and -	+
2	49	7 and 12	4-5 and 5-6	10 and 4	+ and +	+
3	66	7	3-4	13	+	+
4	76	11	3-4	13	-	+
5	67	10	4-5	15	+	+
6	71	2	3-4	13	-	-
7	62	2	6-7	15	+	+

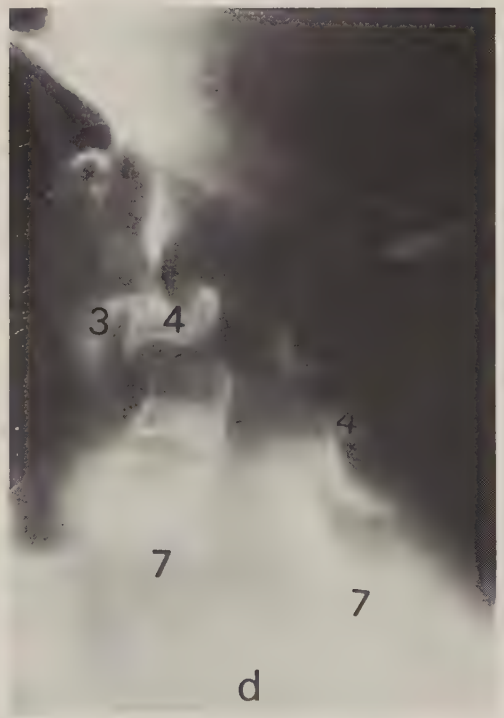
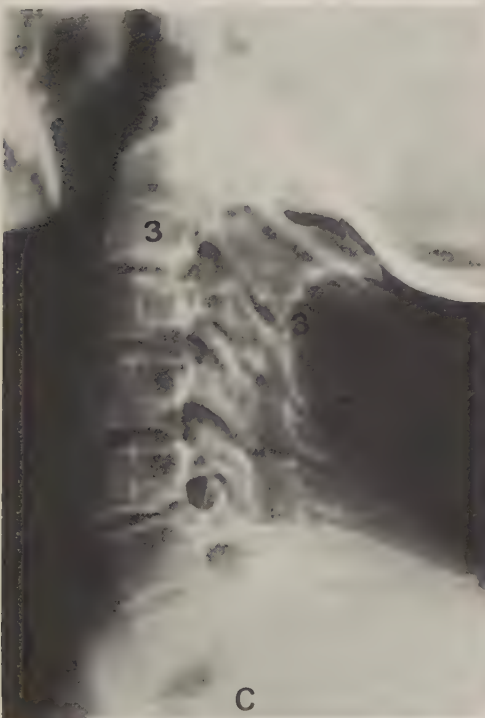
Fig 1. (Opposite side) CASE 1. a) Cervical lateral radiograph from 1971 with no arthritic changes of the subaxial region. Sagittal spinal diameter was 20 mm at the C3 - C4 level. b) Lateral radiograph from 1974 with small subaxial dislocations at C3 - C4 and C4 - C5 levels. c) Lateral cervical radiograph from 1978 with a deterioration of the dislocation at the C3 - C4 level, as well as of other arthritic changes. d) Lateral tomogram of the cervical spine in 1981 showing the remnants of the body of the C3 vertebra situated in front and slightly caudad to the C4 body. The spinous process belonging to C3 is situated dorsally to the C4 body and above the corresponding process of C4. Sagittal spinal diameter is diminished to 10 mm. There are also severe changes at the C6 - C7 level.

tients had clinical neurological symptoms but three of those had a more severe encroachment of the cervical spine at the atlanto-axial level, so the symptoms were more probably due to that high dislocation. Only the subsiding symptoms of case number 2 and the preserved symptoms of case number 3 are regarded to be due to the subaxial vertical dislocation. Those 2 patients had slight weakness of the arms but patient number 2 had also a weakness of the legs that was regarded, in this patient with below-knee bilateral amputation, as not with certainty due to a cervical myelopathy. She had a very narrow spinal canal and at postmortem examination there were extensive neuropathological findings in the spinal cord. Only 2 of the 6 patients are still alive.

DISCUSSION

The first case of rheumatoid cervical arthritis with serious consequences was reported in 1951, a case with vertical dislocation (13) and several reports of cervical RA has followed (1, 2, 3, 9, 11). In some studies the body of the C3 is reported to enter the atlas ring (11), an extension to the middle cervical spine of the atlanto-axial vertical dislocation. But there seems not to have been any report of a true vertical dislocation of the subaxial cervical spine in RA.

This type of dislocation is partly different from the shortening of the neck occurring in malignant destruction of the verte-



bral bodies. In RA the lesions starts in the apophyseal joints and the intervertebral discs and first thereafter there will appear arthritic destruction of parts of the vertebral bodies. In metastatic disease it is nearly always primarily a destruction of the vertebral body, mostly without dislocation of the posterior elements of the vertebrae.

In traumatic cases subaxial vertical dislocation might occur but this is unlikely to appear without severe neurological deficits. In RA the development of dislocations is more insidious which may give the spinal cord a chance to adapt itself to the diminishing space. But still it is astonishing that case number 1 had no severe neurological disturbances. The explanation may be that she had a congenitally very spacious spinal canal with an original sagittal measure of 20 mm which diminished to 10 mm.

The present material with 7 patients with subaxial vertical dislocation indicates that this dislocation is seldom appearing, but not extremely rare.

The subaxial vertical dislocation will only appear in severe mutilating RA with a partial destruction of the vertebral bodies, laminae and pedicles with damage to the longitudinal ligaments of the cervical spine. The dislocation may stop to precede when a bony fusion appears.

SUMMARY

Subaxial (below the C2) vertical dislocation is in the present study defined as a dislocation downwards of a vertebral body to the same plane, partly or wholly as a lower vertebral body. In rheumatoid arthritis the dislocation is combined with erosive lesions of the vertebral bodies. In the present retrospective study 7 such cases are presented. All were middle-aged or elderly women with a long duration of disease and all had an antero-posterior dislocation at the same level. Two patients had this dislocation at more than one level of the cervical spine and in

two patients there was an encroachment of the spinal canal. Most patients had also dislocations at the atlanto-axial level. Neurologic sequelae were rare.

KEY WORDS: Rheumatoid arthritis

Cervical spine

Subaxial vertical dislocation

Subaxial antero-posterior (horizontal) dislocation

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